

NASA Contractor Report 3922(12)

## USSR Space Life Sciences Digest

### *Issue 10*

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NASA Contractor Report 3922(12)

# USSR Space Life Sciences Digest

*Issue 10*

*Edited by*

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\* Topics marked with \* have no entries of their own, but refer readers to relevant abstracts included in other topic areas.

## Reader Feedback Form

To our readers: We are working in a large number of highly technical, specialized areas for which adequate Russian-English glossaries have yet to be compiled. We ask your help in improving the accuracy and specificity of our English terminology. Please fill out the form below whenever you encounter an incomprehensible, incongruous, awkward or otherwise inappropriate term. While we solicit all suggestions for improved renderings, the statement that a term is inappropriate provides us with useful information, even when no better alternative can be suggested. A copy of this form will appear in all future issues of the Digest. Thank you for your help.

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## FROM THE EDITORS

This is the tenth issue of the USSR Space Life Sciences Digest. Due to a number of factors wholly or partially beyond our control, we have gotten somewhat behind on our publication schedule. In order to catch up and improve the timeliness of the information we provide, we are planning to make the next issue (11) a double one, covering papers in the next two issues [20(6) and 21(1)] of Space Biology and Medicine, as well as articles in other journals and monographs. Readers' attention is called to our two special features, one on the "Mir" space station, and the other excerpts from the diary of a participant in a Soviet isolation experiment, which we believe are of more than usual interest.

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**ADAPTATION:** See Biological Rhythms: P408; Hematology: P449;  
Immunology: P450; Metabolism: P430; Musculoskeletal System: P446;  
Neurophysiology: P445; Radiobiology: P432

#### **BIOLOGICAL RHYTHMS**

(See also: Neurophysiology: P445)

#### **PAPERS:**

P408(10/87) Stepanova SI.

**Major trends in the use of biological rhythms for cosmonaut selection.**

In: M97(Digest Issue 9) Stepanova SI.

Biologicheskiye aspekty problemy adaptatsii

[Biological aspects of the problem of adaptation].

Moscow: Nauka; 1986.

Part II, Chapter 2, pages 165-171.

Biological Rhythms, Sleep-wakefulness Schedules; Human Performance, Work  
Capacity  
Humans; Personnel Selection, Cosmonauts  
Adaptation, Space Flight

Translation of Chapter: The present work rest schedule of cosmonauts in space uses on a 24-hour day and stipulates the alternation of periods of sleep and waking at the normal "Earth" times [for all crewmembers]. Obviously, this means that no crewmember is on duty during the period designated for sleep. However, the possibility that a cosmonaut will be required to be on duty at all times, either for an entire flight or during certain critical periods, has not been ruled out for future flights. This could be achieved in two ways: either by alternating shifts, with each cosmonaut having morning, evening, or night watches at different times; or by assigning each cosmonaut to a fixed shift. In the latter case, one crewmember would always work during the usual period, i.e., during the day according to Earth time, (this will most likely be the captain, who as the person with the greatest responsibility for the fate of the flight, should have the optimal schedule), while another crewmember will have to adjust to working at night. This, would entail realigning the diurnal rhythms of his body's vital functions. The faster this realignment is achieved, the sooner the crewmember can return to his peak working condition and the shorter the period of desynchronization, with its unavoidable decrease in well-being and work capacity.

Obviously, for such flight schedules, it is best to select people who will most readily adapt to shift work and to a single phase shift in sleep-wakefulness rhythms. Information needed for such selection can best be obtained when potential crewmembers are maximally isolated from their accustomed physical and social environments, simulating the lack of 24-hour synchronizers during space flight. As a standard test of the flexibility of an individual's circadian rhythms (i.e., his capacity to adapt to a one-time phase shift), we recommend day-night inversion (12-hour phase shift of the sleep-wakefulness rhythm. Compared to phase shifts of smaller magnitude, inversion has the advantage of resulting in the most pronounced changes in diurnal rhythms, simplifying measurement and allowing utilization of existing data analysis techniques. Potential cosmonauts must be tested individually. Studies designed to identify individual differences in biological rhythms should not use a group isolation paradigm, because group members may influence each other's diurnal rhythms.

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The duration of a single study after day-night inversion should be 15-20 days, and a shift to an altered work and rest schedule should be studied for no less than 1 month. A 10-day preliminary study should be performed during which the subject follows his normal schedule so his initial state can be determined.

The rate of adaptation to shift work and an inverted schedule can be gauged on the basis of sleep quality, general well-being, cognitive efficiency, and state of diurnal physiological rhythms. It is self-evident that the greater the number of such rhythms measured the more complete and reliable the assessment of the individual's adaptive capacities will be. It is essential to observe the most inert processes (including diurnal rhythms of renal excretion of potassium), since these are the most resistant to realignment and are thus critical in determining rate of adaptation to unfamiliar living schedules.

Adaptation to a single displacement in the phase rhythm of sleep and wakefulness can be studied under naturally occurring conditions after a flight to a remote time zone (e.g., from Moscow to Petropavlovsk-Kamchatskiy). When such studies are performed, it must be remembered that adaptation occurs more rapidly than in isolation because of the facilitating effects of physical and social time indicators.

If a space flight is to use a day that is longer or shorter than 24 hours, then it is desirable to select crewmembers on the basis of their capacity to adapt to such a day. Tests for individual differences in this parameter should also be performed on isolated subjects. The duration of the study will depend on the specific characteristics of the new living schedule, and is difficult to estimate even approximately. In any case, such studies also require an additional 10-day period for preliminary recording of vital functions under a normal sleep-waking schedule. The duration of the study period under the altered schedule will also be no shorter than 10 days.

Another methodology is possible: the period of the individual's natural circadian rhythm can be observed. This requires 10 days for a preliminary study of rhythms under normal conditions, plus 20 or 30 days during which the subject is allowed free choice of his schedule.

Examination of the biological rhythms of potential cosmonauts should also include some estimate of the stability of an individual's circadian rhythms. In the initial stage this task should be directed not at selection, but at rank ordering the potential candidates on the basis of this parameter. (Of course, this does not exclude the possibility of a negative selection recommendation for a candidate who shows pronounced lability in the parameters recorded, particularly in the case of the most vital rhythms.) The data obtained from examinations are useful for estimating characteristic baseline diurnal rhythms in vital functions. (The more such rhythms included in the study, the better.) A comparison of these data with the results of a medical examination of the members of space crews during flight, including their self-reported general state, work capacity, and the extent and duration of their reactions to weightlessness during the initial period of the flight can extend our understanding of the correlation between the stability of an individual's circadian rhythms and



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his capacity to adapt to space flight stress factors (i.e., his resistance to the desynchronosis induced by these factors).

If the diurnal rhythms of cosmonauts' vital functions are to be recorded during space flight for the purpose of studying the effects of flight conditions on the circadian system, results of preliminary ground studies can serve as the baseline for estimating the extent and direction of changes in flight.

Studies of the stability of diurnal rhythms can best be performed in a sanatorium or a hospital of similar type. During such a study physical, functional and emotional stress must be completely eliminated. The diet must be free of irritating (spicy or pickled) dishes and standardized in amount of protein, fats, carbohydrates and minerals, and fluid consumed in a day. The design of such an experiment was described in a previous chapter. A study such as this should last at least 10 days.

Study of the stability of diurnal rhythms may be combined with study of their flexibility. In this case, stability is estimated on the basis of data obtained during a 10-day baseline study preceding a phase shift in the sleep and wakefulness cycle (see above).

In examining the biological rhythms of cosmonauts, it is very useful to identify the type of diurnal rhythm in work capacity ("morning," "night," or "intermediate") for each individual. Such a study, is very simple to perform. Cosmonauts belonging to the "night" type will do more productive work at night than will those belonging to the other groups. If during the flight it becomes necessary to shift bedtime to an earlier hour (e.g., to 20:00), "morning" types ("larks") will adapt more readily, while shifting the beginning of the sleep cycle to a later hour (e.g., to 3:00 or 4:00) will be less disturbing to "night" types ("owls"). One should also bear in mind that "owls" are better able to tolerate frustration, allowing them to be more reliable under the difficult conditions of space flights, which are fraught with unanticipated problems.

The trends we have described in the use of biological rhythms in cosmonaut selection are primarily directed at minimizing space desynchronosis. Susceptible individuals are the most likely to develop pathological forms of desynchronosis with sleep disturbance, neurosis, and gastrointestinal disorders and should not be accepted as candidates for space flight. These individuals are also likely to make the greatest numbers of errors during job performance while suffering from desynchronosis. They are the ones from whom we can anticipate the most pronounced decrements in biological and performance reliability under exposure to desynchronizing factors.

The danger and possible consequences of desynchronosis in space are by no means universally acknowledged by those who provide biomedical support for space flights. It has been asserted, for example, that desynchronosis caused by a phase displacement in the sleep and wakefulness cycle is short-lived. When phase displacement is of small magnitude, this is indeed the case. However, even on Earth, displacements as great as day-night inversion are accompanied by desynchronosis lasting no less than 2 weeks. And in space there are a number of additional desynchronizing factors

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(weightlessness, altered time cues, emotional tension) which tend to worsen and prolong the desynchronosis caused by disruption of the sleep-wakefulness cycle. Data obtained in space, as well as theoretical considerations, have convinced us that this is indeed the case. V.A. Degtyarev, et al. [1980] tell us that during days 21-39 of the flight of the prime crew of the "Salyut-5" station, when the sleep-wakefulness cycle was displaced almost 6 hours in either direction, the spacecraft commander suffered an autonomic crisis (the symptoms of this crisis, judging by a description by N.M. Rudnyy, et al. [1977], included unpleasant sensations in the area of the heart, general weakness, perspiration, increase in blood pressure to 150/80), while the flight engineer suffered from sleep disorders. Subsequently, the crewmembers were given an additional rest period, resulting in an improvement in the captain's state. However, the flight engineer continued to suffer from sleep disorders, and symptoms of fatigue increased and were complicated by headache, and accompanied by disruptions in the regulation of vascular tonus. Examination of the cosmonaut during this period revealed high lability in blood pressure and a substantial increase in minute volume of the blood, inappropriate to a resting state. Even on day 40 of flight, when the day-night schedule was close to normal, the stroke and minute volume of the blood significantly exceeded preflight levels. The difference between actual and working peripheral resistance was greater than 15%, suggesting decreased vascular tonus. These symptoms were accompanied by decreased tolerance of provocative tests involving physical exercise and LBNP. The authors evaluate these phenomena as being near-pathological.

Thus, the negative consequences of disruption of the sleep-wakefulness schedule, observed during days 21-30 of the flight, were treated successfully in only one crew member; the second cosmonaut displayed low tolerance for desynchronosis, as manifested in progressive deterioration of his health, attaining a prepathological level, in spite of the fact that the sleep-wakefulness schedule returned to normal. This demonstrates that reestablishing well-being diminished by disruption of the daily schedule in space may be virtually impossible. For this reason, it is essential to adhere rigidly to a 24-hour sleep-wakefulness schedule in space, disallowing even isolated or very short-term exceptions, and also, of course, to use properties of biological rhythms in order to select cosmonauts maximally resistant to desynchronosis.

Sometimes one hears that desynchronosis is not a "critical factor" in space flight and does not lead to serious health problems or noticeable decreases in work capacity. In reply we offer the following considerations.

Desynchronosis has not been specifically studied as an independent phenomenon on a single manned flight. However, symptoms of desynchronosis, mainly sleep disturbances, were observed in space in both Soviet and American cosmonauts. D. Lindly [1974], listing the various disorders cited for members of Soviet and American spacecraft crews, notes "some desynchronosis of circadian rhythms", referring, evidently, to disruption of the sleep-wakefulness rhythm and its misalignment with the other diurnal rhythms of the body. This authors of the book "Man on long-term space flights" agree: "Sleep disorders and desynchronosis between the sleep-wakefulness cycle and other rhythms, as well as poor adaptation to the new schedules of sleep, work and leisure were noted during short-term space

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flight, if only in the form of notations in flight journals. But there is very little hard data on the subject" (page 35). These authors conclude that, "One gets the impression that sleep and work-rest schedules will become extremely troublesome during longterm manned spaceflights."

With regard to space flight, how can we call an effect which leads to decreased work capacity and potentially dangerous errors in job performance in cosmonauts a "non-critical factor?" An error made by a cosmonaut may lead directly and immediately to an emergency situation. For this reason, desynchronosis, which increases the probability of errors in the performance of job tasks, must be considered a "critical" spaceflight factor.

It should be noted that individuals who are resistant to desynchronosis can adapt to unfamiliar rhythms with lower psychological and neurological cost, a fact which is very important from the point of view of maintaining a good psychological climate on board a spacecraft. In one study, performed on a small group of people isolated from the outside world, [Rockwell, et al., 1975], a sudden 8-hour phase displacement of the sleep-wakefulness cycle was accompanied by immediate and significant increase in depression, aggression, and hostility. If the participants in this study had been previously selected for resistance to desynchronosis, such consequences, undoubtedly, would have been considerably less pronounced.

The problem of selecting cosmonauts on the basis of their biological rhythms was posed soon after the first manned space flights. B. S. Alyakrinskiy noted in 1966 that, "The development of a methodology for studying individual differences in human adaptation to artificial diurnal rhythms is of great significance." This same author expressed this idea in a different work in 1967. The author of "Man on long-term space flights" describes discussion of the use of biological rhythms in cosmonaut selection in the USA. Various aspects of this problem were considered in a work by S. I. Stepanova [1975]. "It is particularly important to take diurnal rhythms into account," wrote I.P. Levshina and K. Gekht [1979], "in the selection of industrial workers, pilots, cosmonauts and nurses, i.e., people in professions where there is shift work or frequent changes in schedules. In doing this, individual differences in sensitivity to phase shifts and in the capacity to adapt to a new schedule should be identified." The urgent need to use biological rhythms for selection in aviation is emphasized by V.F. Onishchenko and F.V. Babchinskiy [1980]. "Starting from knowledge of the principles governing biological rhythms," they write, "specialists have identified two types of people: those with flexible biological rhythms, who easily and rapidly adapt to new conditions, and those with inert biological rhythms, whose adaptation to new conditions is painful and slow. From a practical point of view, the flexible individuals are best suited for long flights crossing time zones. This suggests the desirability of introducing procedures based on biological rhythms for selecting flight crews for long flights into the practice of space medicine." The development of methods for using biological rhythms in selection and their adoption in the practice of space medicine is an urgent goal.

P418(10/87)\* Alpatov AM, Klimovitskiy VYa.

**The splitting of the body temperature rhythm of monkeys undergoing hypokinesia with head-down tilt**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 37-41; 1986.

[12 references; 4 in English]

Biological Rhythms, Body Temperature, Diurnal Rhythms  
Primates, Rhesus Monkeys  
Hypokinesia, Head-down Tilt

**Abstract:** A single Macaca rhesus monkey was maintained under a light darkness ratio of 16:8 (light from 8:00 to 24:00) and air temperature of 20-22°C. The animal was restrained in a device with head-down tilt of -6°. A temperature gauge was attached to its shaved leg to measure skin temperature and another was placed in its armpit to measure body temperature. The region where the body temperature was measured was thermally insulated by covering it with a sheet of porolon. Temperatures were recorded automatically and continuously and were read into storage every 16 minutes for a period of 14 days. Two additional monkey restrained in a sitting position were used as controls. Starting at day 5 of treatment mean diurnal values of both temperatures began to drop, reaching a minimum on day 11, and then approaching normal value. During hypokinesia the amplitude of the skin temperature rhythm first decreased, with the minimum occurring on day 4, returned to normal on day 8, and subsequently increased beyond normal. Rhythms of 4, 6, 8, and 12 hours occurred and the primary 24 hour component split into two parts with periods of 18-19 and 25-26 hours. Subsequently the phase rhythm returned to its baseline value, by day 10. Amplitude of this parameter increased monotonically and at day 7 was 4 times its baseline level. The body temperature rhythm split into 2 components, morning and evening. Splitting of body temperature rhythm was first noted on day 5, when a secondary "evening" maximum occurred. Every day for the subsequent 6 days, both a morning and evening peak were noted, while in the middle of the day, when the normal maximum typically occurs, there was a decrease in body temperature which was even more pronounced than that noted during the night. The authors hypothesize that the effects noted (splitting of the diurnal body temperature rhythm and decrease in the amplitude and delay of the phase of skin temperature) are associated with weakening of the relationship between the two circadian clocks, which itself has resulted from stress placed on the body's adaptative capacity by hypokinesia with head-down tilt.

Figure 1. Skin temperature and body temperature of a monkey under conditions of hypokinesia with head-down tilt

Figure 2. Changes over time in circadian rhythms of body temperatures

Figure 3. Periodogram analysis

## BIOSPHERICS

### MONOGRAPH:

M102(10/87) Kiyenko YuP, P. Shtefanovich (Hungary), et al., editors.

"Salyut-6" izuchaet biosferu. Issledovaniye prirodnoy sredy iz kosmosa po Sovetsko-Vengerskoy programmy "Biosfera-M"

[Salyut-6 studies the biosphere. Research on the natural environment from space in the Soviet-Hungarian "Biosphere-M program].

Moscow: Mashinostroyeniye; 1986.

[144 pages; 59 photographs and figures; no references cited]

Affiliation: Central Geodetic and Cartographic Administration, USSR Council of Ministers; Hungarian Academy of Sciences

**Key Words:** Biospherics, Remote Sensing, Environmental Studies; "Soyuz-35," "-36," "Salyut-6"

Annotation: During a 7-day period in 1980, a Soviet-Hungarian crew, consisting of USSR cosmonaut pilot Valeriy Kubasov and Hungarian cosmonaut Bertalan Farkash, performed scientific, technological, and biomedical research on board the "Soyuz-35"-Salyut-6-Soyuz-36 orbital complex in cooperation with its primary crew, consisting of L. Popov and V. Ryumin. Some of the most important work performed on the flight involved the "Biosphere-M" experiment.

This book of photographs contains some of the results of the flight and ground-based studies and experiments performed within the Soviet-Hungarian "Biosphere-M" program, which dealt with study of the surface of the Earth through remote sensing.

This book contains a large number of previously unpublished photographs of our planet taken from the Salyut-6 space station. It is intended for specialists in biospherics, but is likely to be of interest to a broad range of readers.

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M103(10/87) Moyseyeva NI, Lyubitskiy RYe.

Vozdeystviye Geliogeofizicheskoye faktorov na organizm cheloveka

[The effects of helio-geophysical factors on the human body].

Volume 53 in series: Problemy Kosmicheskoy Biologii [Problems in Space Biology].

Leningrad: Nauka; 1986.

[136 pages; 47 tables; 24 figures; 201 references]

Affiliation: Not available

**Key Words:** Biospherics, Radiobiology, Solar Radiation, Geomagnetic Activity

**Annotation:** This book presents the results of research on the influence of helio-geophysical factors on the human body. Included in the book are analyses of the effects on humans of components of the Earth's natural geomagnetic field, magnetic storms, solar flares, solar radiation of various wavelengths on humans, as well as the results of research on unithiol probes and the sector structure of the interplanetary magnetic field. The authors describe the effect of weather factors (air temperature, humidity, and atmospheric pressure) on physiological parameters of healthy and sick individuals. They examine the possible mechanisms through which helio-geographic factors influence the human body. They describe analysis techniques used in helio-geophysical experiments and present a detailed discussion of their own method, which allows identification of both linear and nonlinear correlations.

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P436(10/87)Podluts'kiy, AG.

**Cytochemical localization of  $\text{Ca}^{2+}$ -ATPase under normal conditions and during clinostatting.**

Ukrainian Botanical Journal

43(4): 82-84; 1985

Author's affiliation: M.G. Kholodnoy Botanical Institute, Uk. Academy of Sciences

[9 references; 7 in English]

Botany, Cytochemical Localization,  $\text{Ca}^{2+}$ -ATPase  
Pea Plants, Roots  
Clinostatting

[Note: original in Ukrainian; Russian abstract was translated.]

Abstract: Cytochemical localization of  $\text{Ca}^{2+}$ -ATPase activity in cells of various zones of 7-day-old pea plant roots showed well-defined differences in the localization of this enzyme under conditions of slow clinostatting (2 rev/min,) in comparison to a stationary control. This was most pronounced in cells of the central statenchyme and meristem, in which the intense enzymatic reactions of the plasmalemma characteristic of the cells of the stationary control group were minimal under clinostatting.

Figure 1. Localization of the products of cytochemical reactions with  $\text{Ca}^{2+}$ -ATPase in central statenchyme cells of 7-day-old pea plant roots; a - control (X 58000); b, c -clinostatting at 2 rev/min (X 28,000 and X 50,000, respectively).

Figure 2. Localization of the products of cytochemical reactions with  $\text{Ca}^{2+}$ -ATPase in the central statenchyme cells of 7-day-old pea plant roots; a, b, c - control ( X 40,000, 35,000, 24,000 respectively), d -clinostatting at 2 rev/min ( X 55,000)

P437(10/87) Vasilenko OI.

Changes in level of ATP in cultures of Haplopappus gracilis (Nutt) A. Gray in the initial stages of clinostatting.

Ukrainian Botanical Journal.

43(4): 84-85; 1986.

Author's affiliation: M.G. Kholodnoy Botanical Institute, Ukrainian Academy of Sciences

[6 references; 2 in English]

Botany, ATP; Cytology

Haplopappus

Clinostatting

[Note: original in Ukrainian; Russian abstract was translated.]

Abstract: This paper describes the study of the concentration of ATP in a culture of Haplopappus cells during the initial stages of clinostatting. ATP was measured using the luciferin-luciferase enzyme system. It was demonstrated that during clinostatting the concentration of ATP increases substantially, undergoing pulsating (wave-like) changes. This tendency was retained in cultures in various growth phases. The possibility of decreases in the activity of energy-dependent movements in the cytoplasm is discussed.

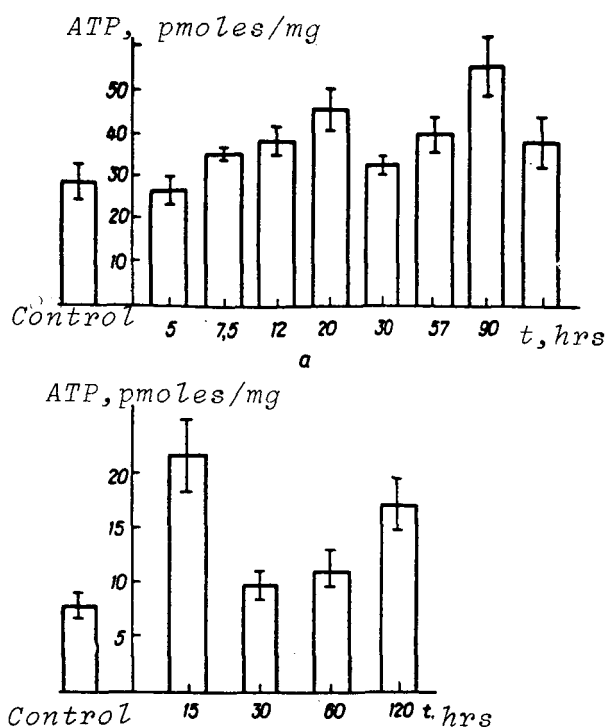


Figure: Concentration of ATP in cultures of cells of Haplopappus gracilis (Nutt) A. Gray; a, b - respectively on the 14th (illumination  $6.72 W/m^2$ ) and 33rd (illumination -  $3.36 W/m^2$ ) days of growth during clinostatting, Ordinate: concentration of ATP pmoles/mg of dry weight, abscissa - hours of clinostatting

P438(10/87) Zhad'ko SI.

**Early reactions of pea shoots to clinostatting.**

Ukrainian Botanical Journal.

43(4):86-87; 1986.

Author's affiliation: MG Kholodnoy Botanical Institute, Ukrainian Academy of Science.

[10 references; 2 in English]

Botany, Growth, Lipid Peroxidation, Antioxidation

Peas, Shoots

Clinostatting

[Note: original in Ukrainian; Russian abstract was translated.]

Abstract: It was established that toward the end of the first and third days of clinostatting, growth processes (length, increase in weight of dry and wet substance of the main root) decrease by an average of 25-40%. At the same time data from chemoluminescent analysis and concentration of malonic dialdehyde and antioxidants indicate the tendency for the rate of lipid peroxidation to decrease and for antioxidative activity to increase in the cells of the apex (zone of the meristem and root cap). The latter is a consequence of the occurrence of adaptive processes directed at maintaining homeostasis under conditions of clinostatting.

P440(8/87) Aliyev AA, Abilov ZK, Mashinskiy AL, Ganiyeva RA, Ragimova GK, Alekperov UK.

**The ultrastructure and physiological characteristics of the photosynthesis system of shoots of garden peas grown for 29 days on the "Salyut-7" space station.**

Izvestiya Akademii Nauk Azerbaydzhanskoy SSR. Seriya biologicheskikh nauk. 1985(6): 18-23.

[11 references; 3 in English]

Botany, Ultrastructure, Photosynthesis System

Peas, Shoots

Space Flight, "Salyut-7"

Note: This paper is highly similar to the one abstracted as P313 in Digest Issue 8 (page 15). However, because of the importance of the material and the presence of figures absent in the previous article we are including it.

Abstract: This study was performed on pea sprouts grown for 29 days on the "Soyuz-7." Plants grown in the laboratory under identical light and growth conditions served as controls. Fragments of leaves from various layers of the plants were fixed, dried, encased in polymers and analyzed using an electron microscope. Chlorophyll composition was studied spectrophotometrically. Comparative analysis of the ultrastructure of cells from the palisade mesophyll of leaves of flight and control plants revealed substantial morphological differences. Chloroplasts of flight plants contained only a few scattered small grains of starch, if any. The ribosome structures were less dense than those of control plants and had no sharply demarcated zones containing chloroplast DNA. The most pronounced effects occurred in the granular-thylakoid membrane system of the chloroplasts. The flight plants contained organelles with normal membrane systems, and chloroplasts with looser, less dense membranes with disorientation or separation of the thylakoids. The chloroplast cells of the palisade parenchyme of flight plant leaves contained vessicularized stroma. The authors associate these vessicles with fragmentation and swelling of the thylakoids which, they postulate, may have resulted from inhibition of synthesis of structural proteins within the plastids. They further hypothesize that the inhibition of protein synthesis within chloroplasts may be an adaptive response on the part of the organelles to space flight conditions.

Comparative analysis of absorption and fluorescent spectra of leaf homogenate from the flight and control plants revealed some adaptive modifications in the functioning of the photosynthesis system. In the low temperature absorption spectra, the flight plants contained more long-wave chlorophyll "a" and less chlorophyll "b" (not confirmed by table) than controls. In the fluorescent spectra, the ratio between intensity of the short wave fluorescence to long-wave fluorescence was altered in the flight plants.

P440

Table: Concentration of pigments, and their sum with respect to the total concentration of chlorophyll in flight (F) and control (C) pea plants

Pigment, mg/g	C	F	C	F	C	F	C	F
Chlorophyll a	1.43	2.25	1.41	2.42	1.40	2.39	1.39	2.40
Chlorophyll b	0.61	0.96	0.59	0.92	0.58	0.88	0.57	0.89
Chlorophyll a+b	2.04	3.48	2.00	3.34	1.98	3.27	1.96	3.29
Chlorophyll <u>a+b</u>								
Chlorophyll a-b		1.70		1.67		1.65		1.68

NOTE: FIGURES IN OUR COPY OF THIS PAPER ARE TOO ILLEGIBLE FOR REPRODUCTION

Figure 1: Low temperature absorption spectra (a, b) of homogenates of pea plant leaves and their first derivatives (a', b')

Figure 2: Low temperature florescence spectra of homogenates of pea leaves  
a - control; b -- flight.

P441(10/87) Tayrbekov MG, Grif VG, Barmicheva YeM, Valovich YeM.  
**Cytomorphology and ultrastructure of the root meristem of corn in weightlessness.**

Izvestiya Akademii Nauk SSSR. Seriya Biologicheskaya.

1986(5): 680-687.

[21 references; 10 in English]

Authors' affiliation: Institute of Biomedical Problems, USSR Ministry of Health; V. L. Komarov Botanical Institute, USSR Academy of Sciences, Leningrad

Botany, Morphology and Cytology

Corn, Root Meristem

Space Flight, "Cosmos-1514"

**Abstract:** Subjects of this experiment were corn seeds grown for 8 days on board the "Cosmos-1514" biosatellite. The seeds were soaked for 6-8 hours and then placed in a porolon disk which was sealed in the compartment of an apparatus to which 40 ml of water was added. Every 2 hours the compartment was unsealed and air was blown in to change the atmosphere. Temperature was maintained at 25°C. One of the goals of the experiment was a comparative cytological and electron microscope analysis of the cells of flight and control plant sprouts. The major focus was on the anatomy, cytological characteristics and ultrastructure of cells of the root meristem and cap. Preliminary analysis was made 2 hours after landing, in a field laboratory. Sprouts were photographed, weighed, and measured. A cross-section was taken of five of the plants 30 mm from the end and fixed for cytological analysis. Cytological analysis utilized the following parameters: size of root cap and meristem zone, number of cells in these areas of the root axis, size of the periblem cells and their nuclei, nucleus-plasma ratios, and mitotic index. Material for electron microscopy was cut 15 mm from the end and prepared using standard techniques. Electron microscopy was primarily concerned with the ultrastructure of cells of the root meristem and cap. Synchronous and vivarous ground-based control groups were used for all analyses.

All 14 flight seeds sprouted. Flight seeds did not differ from controls in weight, length or thickness of the roots or coleoptiles. Cytological analyses revealed almost all morphological parameters of the cells of the root cap and meristem to be equivalent for flight and control plants. The one exception to this was a difference in the sizes of the cells of the meristem-periblem proper, which affected the nucleus/ plasma ratio; however, the two control groups also differed from each other in this parameter. Differences in the mitotic index also occurred between all 3 groups. Electron microscopy revealed deposits of slime and secretor vessicles concentrated in the area of the plasmalemma, possibly indicating some decrease in the secretion activity of the outer cells of the root cap in weightlessness. No other deviations in the ultrastructure were found. Electron microscopy of the areas of the gravity receptor statocyte cell occupying the central zone of the root cap - statenchyme revealed no differences between flight and control cells, which the authors attribute to the fact that the first few days of the experiment took place on Earth. The authors concluded that the small differences found in this study are within physiological norms for reactions to external stimuli.

Table 1: Data from initial measurements of corn sprouts

Group	Initial number of seeds	Initial weight of seeds, g	Dry weight of sprouts, g	Length root cole- optile		Width root cole- optile	
Flight	14(14)*	5.01	15.1	100	120	1.0	1.8
Synchronous Control	14(13)	5.05	13.9	95	110	1.0	1.5
Laboratory	14(13)	5.08	14.2	98	108	1.1	1.6

• Number in parentheses refers to number sprouting

Table 2: Cytological characteristics of root meristem of corn sprouts grown in weightlessness and on Earth

Group	Root Cap		Meristem proper (periblem)				MI	
	Length, # cells um	along axis	Length, # cells um	along axis	cell area, um <sup>3</sup>	nucleus area, um <sup>3</sup>		
Flight	265	17	657	70	109.8	37.4	0.35	21.9%
Synchronous Control	267	12	760	75	129.1	32.3	0.25	22.8%
Laboratory Control	268	13	683	62	122.0	35.4	0.30	19.9%



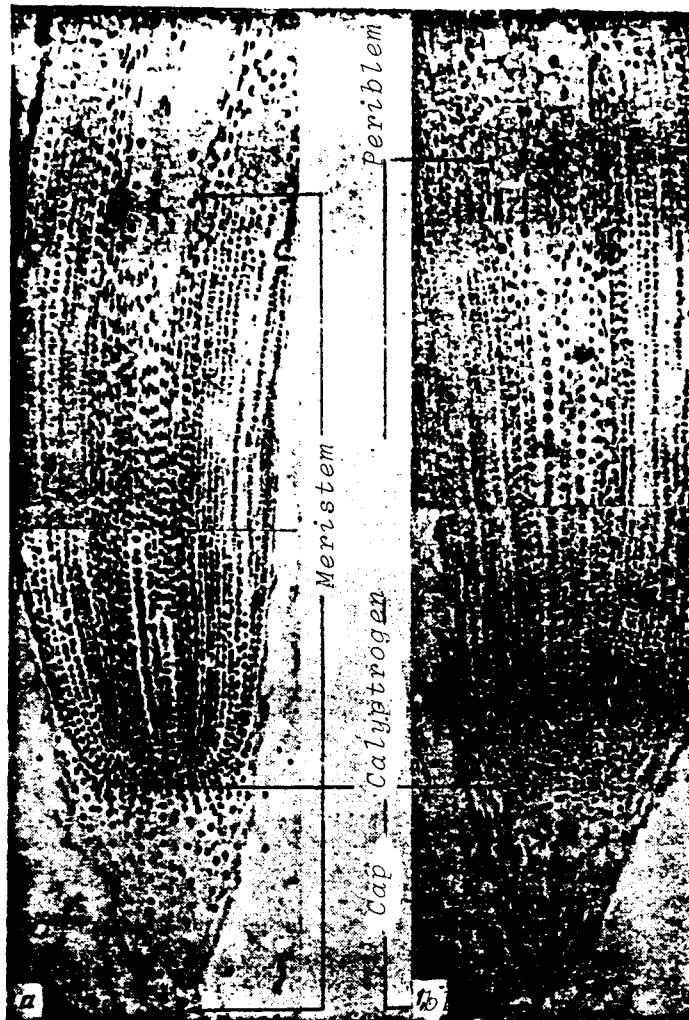


Figure 1: Lengthwise cross section of the root of a corn sprout, root cap and meristem zone. In figures 1 - 4, a - flight (weightlessness); b - synchronous control (Earth)

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P441

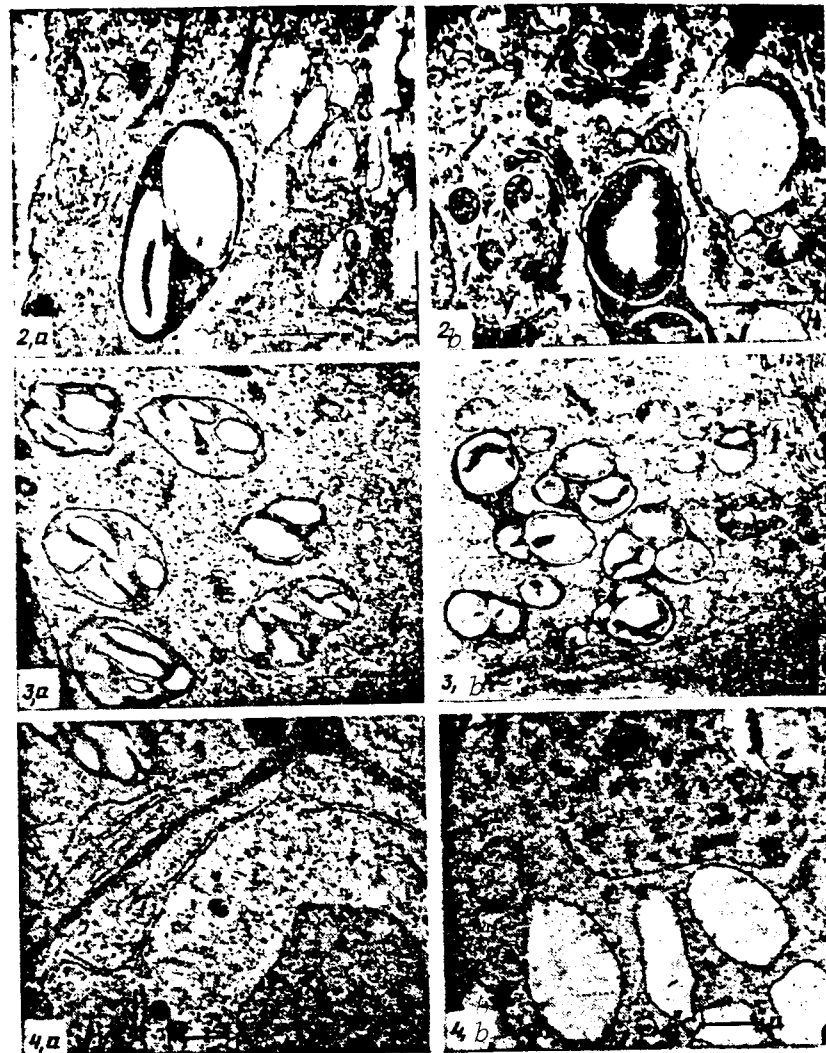


Figure 2. Ultrastructure of a portion of a secretor cell of the root cap

Figure 3. Amyloplasts in a gravity receptor cell of the root cap

Figure 4. Ultrastructure of the meristem cells of the root; a - flight (weightlessness); b - control (Earth)

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## CARDIOVASCULAR AND RESPIRATORY SYSTEMS

(See also: Endocrinology: P439; Neurophysiology: P445)

P425(10/87)\* Breslav IS, Isayev GG, Kochubeyev AV, Sokol YeA.

### **Evaluation of the effect of positive intrapulmonary pressure on human respiratory function.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 64-69; 1986.

[16 references; 7 in English]

Cardiovascular and Respiratory System, Respiratory Function

Humans

Positive Intrapulmonary Pressure, Counterpressure

**Abstract:** This work studied the major parameters of respiration and electrical activity of the respiratory musculature under positive intrapulmonary pressure (PIP) using gas mixtures with varying concentrations of oxygen. Subjects, 6 healthy men, wore breathing masks. Positive intrapulmonary pressure was created by delivering a compressed gas mixture under the mask, regulated using a special valve and monitored with a water manometer. Three levels of PIP were used -- 20, 30, and 40 mm Hg, with exposures of 10, 5, and 2 minutes in duration, respectively. Three breathing mixtures were used: normoxic (air), hyperoxic (pure oxygen), and hypoxic (8.5 - 10% oxygen in nitrogen). The last mixture corresponds to breathing the atmosphere at a height of about 16,000 m above sea level. Two compensating devices were used: CD-1 directed counterpressure to the chest, abdomen and lower extremities, while with CD-2 counterpressure was evenly distributed over the surface of the body. In some trials the 3 standard levels of counterpressure were used with each device. In the remainder of the trials, each subject himself found his own optimal counterpressure. A Fleisch pneumotachograph was used to record volume and temporal data about respiratory cycles. Electromyograms using external electrodes measured the electrical activity of the respiratory muscles. Measurements were made immediately previous to and during the treatment, and for a 5-minute period after its termination.

Positive pressure breathing led to hyperventilation, which increased as intrapulmonary pressure increased. Under pressure of 40 mm Hg, pulmonary ventilation increased by virtue of increases in the respiratory volume. Respiratory rate accelerated as well. Analysis of temporal properties of respiration indicated that the inspiratory phase remained unchanged, while duration of expiration decreased by a factor of 1.5. Mean speed of inhalation and exhalation increased to the same level; peak speed of inspiratory air flow increased by a factor of almost 3. Initial inspiratory activity increased by a like factor. These changes led to significant changes in gas exchange: deep hypocapnia was noted, with  $p_A\text{CO}_2$  dropping to 20 mm Hg. Contrary to expectations, gas mixtures with varying contents of oxygen did not significantly affect changes in respiratory parameters when PIP was 20 or 30 mm Hg. PIP had substantial effects on the activity of the respiratory muscles. Expiratory muscle activity was observed to follow a pronounced phase structure with maximum activity occurring at the termination of exhalation. The electric activity of the inspiratory muscles increased.

P425

There were no differences between the effects of the two types of counterpressure devices at any of the three standard counterpressures used. In all cases, as counterpressure increased, pulmonary ventilation decreased, although it remained above baseline. The major factor leading to decreased ventilation was altered respiratory volume. Compensatory counterpressure had no significant effects on the temporal parameters of the cycle during PIP. As counterpressure increased, the velocity of the inhaled and exhaled air streams decreased, although they remained above baseline. Initial inspiratory activity decreased under counterpressure, but was independent of the level of counterpressure. Expiratory muscle activity decreased regularly as counterpressure increased; no such relationship was observed with inspiratory muscles. The counterpressure preferred by subjects approached the mean of the tested levels. At the preferred counterpressure, the activity of inspiratory muscles approximated baseline levels, while expiratory muscle activity was at a minimum. There was considerable stability in the value of counterpressure selected by a given subject. Neither temporal nor volume parameters approached baseline at selected optimal counterpressure.

The authors conclude that optimal counterpressure can be selected by each individual, so long as it is in general agreement with the criterion of minimal activity of expiratory muscles. They believe that allowing individuals to select their own optimal counterpressure will increase tolerance to PIP during flights.

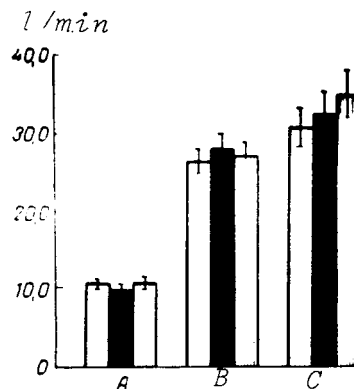


Figure 1: Changes in pulmonary ventilation with different levels of positive intrapulmonary pressure using breathing mixtures with varying oxygen concentrations. A - baseline; B and C - PIP of 20 and 30 mm Hg, respectively; White bars - air; Black bars - oxygen; Striped bars - hypoxic mixture (8.5% O<sub>2</sub> in nitrogen). Ordinate - ventilation (in l/min)

# CARDIOVASCULAR AND RESPIRATORY SYSTEMS

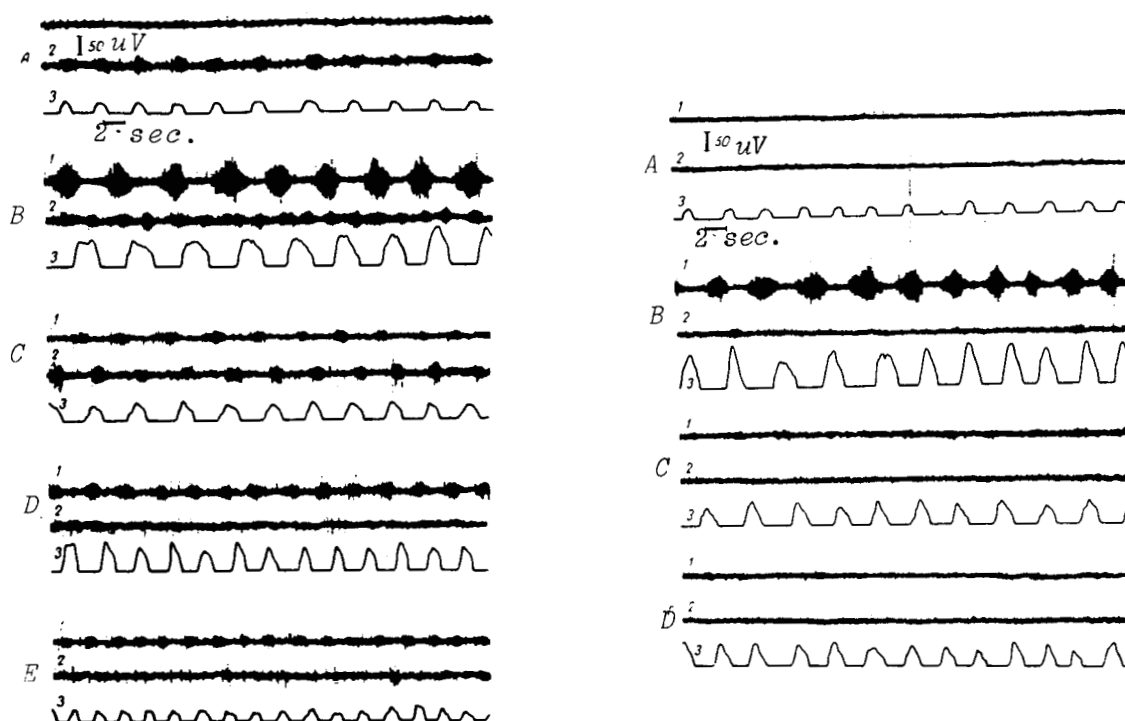


Figure 2: Electrical activity of expiratory and inspiratory muscles during PIP breathing under varying levels of compensatory counterpressure.

Here and in Figure 4: 1 and 2 - electromyograms of expiratory and inspiratory muscles, respectively; 3 - pneumotachyogram. A - air at atmospheric pressure; B - PIP 40 mm Hg without compensation; C, D and E - PIP 40 mm Hg, using lowest, middle and highest levels of counterpressure

Figure 4: Electrical activity of expiratory and inspiratory muscles under normal conditions, and during PIP with or without counterpressure

A - air at atmospheric pressure; B - PIP, 40 mm Hg without compensation; C and D - PIP, 40 mm Hg with optimal counterpressure in one experiment with an interval of 10 minutes.

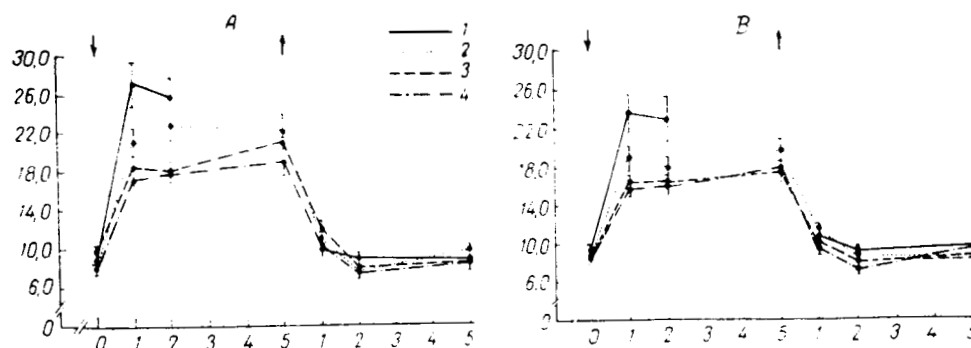


Figure 3: Pulmonary ventilation with two types of compensatory devices as a function of counterpressure used, with PIP at 40 mm Hg

Abscissa - time (minutes); Ordinate - (l/min); arrows indicate beginning and termination of PIP; A and B - KU-1 and KU-2 devices, respectively; 1 - PIP without counterpressure; 2, 3 and 4 - PIP at lowest, middle and highest levels of counterpressure, respectively

P434(10/87) Shashkov VS, Modin AYu.

**Problems and prospects in pharmacological correction of orthostatic [in]tolerance in space medicine.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 4-11; 1986.

[64 references; 21 in English]

Cardiovascular and Respiratory Systems, Orthostatic Intolerance,

Hemodynamics

Humans, Review Article

Space Flight, Pharmacological Countermeasures

**Abstract:** This review article considers existing and prospective pharmacological means for treating hemodynamic aspects of orthostatic intolerance, particularly intolerance occurring as a result of space flight. According to the authors, possible measures would fall into 3 categories: those which help to restore normal hydration of the vascular bed; those which counteract the pooling of blood in the veins; and those which compensate for the response of arterial circulation to postural decrease in cardiac output. The simplest way to combat hypovolemia involves administration of additional fluid and salts to cosmonauts just prior to return to Earth. In addition, biologically active compounds facilitating fluid retention can be utilized. These include natural hormones produced by the adrenal cortex and their synthetic analogues such as 9-alpha-fluorohydrocortisone. The effectiveness of the latter in restoring the volume of circulating plasma in humans has been demonstrated in weightlessness simulation experiments. However, such measures do not completely eliminate orthostatic intolerance, indicating that hypervolemia is not the sole component of this condition.

Since orthostatic intolerance is associated not so much with a decrease in overall blood volume as with insufficient blood in the upper portion of the body, it is appropriate to look for pharmacological means of restoring normal vascular responses to assumption of an upright position. Under normal circumstances, standing is associated with constriction of the vessels in the lower body. Long periods in actual or simulated weightlessness attenuate this response. The best pharmacological countermeasure would be one which has a selective vasopressor effect on the lower limbs. However, since such a substance does not exist, the solution must be sought in use of either nonselective vasopressor substances (e.g., norepinephrine, mezaton, phenotol) or of substances which stimulate reflexive transmission of excitation [i.e., stimulate synaptic transmission] (e.g., caffeine, phenamine, tyramine). The latter group of substances is considered preferable because those with a direct vasopressor effect frequently lead to hypertension in a horizontal position. In tests of the effects of synaptic transmission enhancers, artificial sympathomimetic compounds (phenamine, ephedrin) have been shown to be more effective in increasing tolerance than natural mediators (epinephrine, norepinephrine). One drug the authors recommend is sydnocarbium (chemical composition not given), which has no effect on subjects in a horizontal position, but enhances pressor reactions when a vertical position is assumed. This preparation has apparently been used successfully in clinical practice, but has not yet been tested for use in space.

P434

To minimize orthostatic intolerance, enhancement of pressor reactions must occur for both the veins and the arteries. However, the vasoconstrictors discussed primarily affect arteries. Pharmacological correction of the mechanisms facilitating venous return of blood is complicated by the fact that many substances which lead to increased venous tonus (e.g., dibazol, papaverinum, euphyllinum), decrease arterial tonus. This means a phlebotonic drug must be sought which has a minimal depressor effect on arterial tonus. In addition, the effects of many of the more potent phlebotonic substances (e.g. dihydroergotaminum) are more pronounced in the horizontal position than in the vertical, and this might lead to undesirable side effects (e.g., increased diuresis) if these drugs were taken during actual or simulated weightlessness. One substance which has a more pronounced phlebotonic effect in an upright position is glivenol (trimvenol), which has the additional beneficial effect of decreasing the permeability of blood vessels. Beta-blockers have been suggested as a means of correcting the decrease in stroke output associated with orthostatic intolerance. However, minute output might not decrease because of the simultaneous increase in cardiac stroke volume. The negative inotropic effects of these drugs and their possible interactions with the effects of weightlessness must be considered before they are recommended for use in space. Whatever drugs are recommended to counteract the orthostatic intolerance associated with long-term space flight, their interactions with the effects of other countermeasures and space flight factors must be considered in detail.

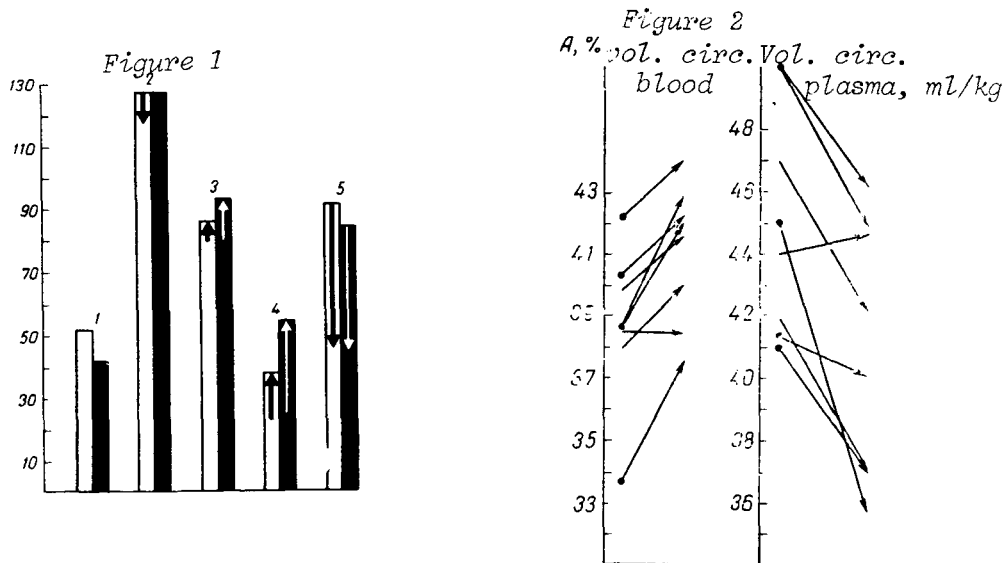


Figure 1. The effect of syndocarb on postural reactions of the human circulatory system 1- postural increase in heart rate (%); 2 - systolic; 3 - diastolic blood pressure (mm Hg); 4 - dicrotic index of a rheovasogram of the calf (%); 5 - cardiac stroke volume. The arrows indicate direction of change in parameters upon assumption of an upright position; white bars -- placebo; black bars -- syndocarbium.

Figure 2. The effect of dihydroergotaminum on distribution of circulating blood and volume of circulating plasma during 6-hour period of head-down tilt ( $115^{\circ}$ ) A- Thoracic fraction of circulating blood; Arrows indicate direction of change in parameters under the influence of the drug; circles are used to designate cases where diuresis increased.

P447(10/87) Gansburgskiy AN.

**The state of the endothelium of the aorta under conditions of hypodynamia [hypokinesia].**

Arkhir Anatomii, Gistologii i Embriologii.

XCI(8): 13- 17; 1986.

[14 references; 3 in English]

Affiliation: Department of Histology, Embryology and Cytology, Yaroslavl Medical Institute

Cardiovascular and Respiratory Systems, Aortal Endothelium; Morphology and Cytology

Rats

Hypokinesia, Psychology, Immobilization Stress

**Abstract:** This experiment utilized 17 control and 30 experimental white male rats. The experimental animals were maintained in immobilization cages for 1 to 30 days. Each day a single rat was removed from the cage and sections of the aortal endothelium removed. Both kidneys were removed and weighed. A quantitative analysis was made of 25 parameters related to the cellular composition of the endothelial lining of the aorta in all experimental and 7 control animals. No significant deviations [from the norm] were found in any parameter in control animals. Pronounced changes were found in the experimental animals starting from the first day of hypodynamia. The proportion of endotheliocytes with cytoplasmic vacuolization, granularization, and lysis increased. A significant number of nonnucleated components were observed, as were cells with karyopyknosis and karyolysis, evidently dying endothelial cells. Monocytes, lymphocytes and blood platelets were found in the endothelium in significantly greater numbers in experimental animals. Mitotic activity increased on the first days of hypodynamia, with a significant portion being pathological. The number of migrating cells, and nuclei with uneven contours and folds increased. From days 5 to 15 of hypodynamia the nuclear area of endotheliocytes increased, leading to an elevated nucleus/plasma ratio. On the basis of their data, the authors divided the 30-day period into stages. During days 1-8, the processes of alteration and cellular hyperplasy increased in the endothelium, corresponding to an emotional stress reaction. Days 11-17 were characterized by increased mitotic activity, which during days 18-22 was accompanied by increased concentration of mitoses and cells with 2 nuclei, and increased size of the endotheliocytes. This is described as a period during which adaptive and compensatory processes predominate. The third period during days 23-30 was characterized by increased alternative processes in the nucleus and cytoplasm, and continued elevated mitotic activity. This led to a decrease in the orderliness in the tissue, as reflected in a decreased number of interacting cells; these changes would tend to increase endothelial permeability. Disruption of lipid metabolism during this period of hypodynamia, along with local destruction of the integrity or permeability of the endothelium may facilitate processes leading to arterosclerosis.

Figure 1: Changes over time in parameters reflecting alternative changes in the endothelia of the aorta under conditions of hypodynamia

Figure 2. Changes over time in parameters reflecting compensatory adaptive transformation of the aortal endothelium under conditions of hypodynamia



**MONOGRAPH:**

M101(10/87) Tkachenko BI, editor.

Fiziologiya krovoobrashcheniya: Regulyatsiya krovoobrashcheniya.

[Circulatory physiology: Regulation of circulation.]

Leningrad: Nauka, 1986.

[640 pages; 983 references; 43 tables; 156 figures]

Affiliation: Book: USSR Academy of Sciences; Editor: USSR Academy of Medicine

**KEY WORDS:** Cardiovascular and Respiratory System, Circulation, Regulation; Metabolism, Vascular Tonus Regulation; Endocrinology, Epinephrine, Vasopressin, Angiotensin, Hypothalamus; Neurophysiology, Conditioned Reflexes, Cerebral Cortex; Postural Responses; Physical Exercise, Acceleration, Weightlessness, Hypoxia, Hyperoxia, Temperature Changes, High Altitudes, Hyperbaria, Hypokinesia; Psychology, Stress, Experimental Neuroses; Mathematical Modeling

Annotation: This book provides an analytical summary of extensive material on the mechanisms underlying regulation of vascular activity. Successive chapters cover myogenic, metabolic, hormonal, and neurological factors involved in regulation, reflexive control mechanisms, and their central links. The regulatory integration of circulation as a whole is discussed in detail. Changes in the circulatory system occurring when an upright position is assumed, during physical exercise and hypodynamia, during changes in air pressure, temperature, or environmental oxygen level, and in the presence of emotional stress and experimentally induced neuroses are analyzed.

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## CARDIOVASCULAR AND RESPIRATORY SYSTEMS

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DEVELOPMENTAL BIOLOGY: See Radiobiology: M98

#### ENDOCRINOLOGY

(See also: Cardiovascular and Respiratory Systems: M101; Metabolism: P430)

#### PAPER:

P411(10/87)\* Afonin BV, Grigor'yev AI, Pavlova YeA.

**The effect of short-term space flights on the activity of the renin-angiotensin-aldosterone system, and the concentration of cyclic nucleotides and prostaglandins of the blood.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 27-30; 1986.

[13 references; 4 in English]

Endocrinology, Renin, Angiotensin, Aldosterone, Prostaglandin, Cyclic Nucleotides; Body Fluids  
Humans, Cosmonauts  
Space Flight, Soyuz

**Abstract:** The study investigates the association between changes in indicators of the activity of the renin-angiotensin-aldosterone system (changes in renin activity in plasma, concentration of aldosterone in blood and its renal excretion), changes in a correlate of activity of the sympathetic adrenal system (concentration of cyclic nucleotides in blood), and indicators of tissue regulation of vascular tonus (pressor and depressor prostaglandins) in response to short periods of space flight. Subjects were 20 cosmonauts who had completed flights varying from 4 to 14 days on Soyuz spacecraft. Blood measurements were made preflight and on days 1, 7, and 14 postflight, while urine was obtained during a 3-day period preflight and a 5-day period postflight. Concentrations of cAMP, cGMP, the F<sub>2</sub> and A+E groups prostaglandins, as well as renin activity in plasma and concentration of aldosterone in blood and urine were measured by radio immune assay. The majority of cosmonauts (group 1) showed increased renin activity and aldosterone concentration in blood on day 1 postflight. The other 4 (group 2) showed decreased renin activity and aldosterone concentration on day 1 postflight. Results of the study for both groups are presented in Table 1. The authors interpret the results as follows. After short-term space flights, renal excretion of aldosterone increases, reflecting accelerated production and metabolism. When metabolism is adequate (group 1), increased aldosterone synthesis leads to its increased concentration in blood, as well as to increased mineralocorticoid activity. Insufficient activation of mineralocorticoids leads to a decrease in aldosterone concentration in blood at the same time that its renal excretion increases (group 2). These differences in mineralocorticoid activity determine the reactions of the renin-angiotensin system, the activity of which is linked not only with fluid electrolyte metabolism, but also with changes in the concentration of cyclic nucleotides and prostaglandins in the blood, reflecting the condition of vascular tonus and the activity of the sympathetic adrenal system. The increase in the activity of the renin-angiotensin system, observed in the majority of cosmonauts during the early stage of readaptation, is correlated with an increase in the concentration of cAMP and a decrease in depressor

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prostaglandins. When, in the minority of cases, the activity of the renin-angiotensin system decreases, the concentration of cAMP also drops.

Table: Renin activity in plasma (in ng/ml/hr), concentration of aldosterone (in pg/ml), cyclic nucleotides (in pg/ml) and prostaglandins (in pg/ml) in blood of cosmonauts in groups 1 and 2

Time	Aldosterone	Renin	cAMP	cGMP	PG A+E	PG F <sub>2</sub>
<b>Group 1 Cosmonauts</b>						
Preflight	38.8 (21)	1.99 (23)	15.5 (16)	5.3 (9)	2.23 (14)	1.55 (14)
Days postflight: 1	80.0** (15)	4.30* (15)	31.1* (10)	6.7 (6)	1.34* (9)	0.62 (9)
7-14	57.7 (6)	2.26 (6)	13.2 (6)	4.5 (5)	2.14 (6)	0.82 (6)
Norm	12-125	0.24-3.24	10-30	1.8-6	2.8-3.2	0.6-10.0
<b>Group 2 Cosmonauts</b>						
Preflight	72.9 (4)	3.07 (7)	13.8 (4)	5.2 (4)	1.31 (6)	0.57 (6)
Postflight day: 1	48.6 (4)	1.64 (4)	9.8 (4)	6.9 (3)	1.47 (3)	0.92 (4)
7-14	26.6 (3)	1.97 (3)	30.0 (2)	6.3 (1)	0.22 (2)	0.20 (2)

Numbers in parentheses refer to number of observations.

\* p < 0.05, \*\* p < 0.005

P433(10/87)\* Davydova NA, Shishkina SK, Korneyeva NV, Suprunova YeV, Ushakov AS.

**Biochemical aspects of the functioning of neurohumoral systems during long-term hypokinesia with head-down tilt.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 91-95; 1986.

[18 references; 4 in English]

Endocrinology, Neurohumoral Systems, Cholinergic, Sympathetic Adrenal;

Neurophysiology

Humans, Males

Hypokinesia, Head-Down Tilt, Long-Term

**Abstract:** Subjects in this experiment were 6 healthy male volunteers, aged 25-40, subjected to 120 days of hypokinesia with head-down tilt ( $-4.5^{\circ}$ ). Venous blood was taken once during a baseline period, on days 25, 56, 70, 92, and 112 of hypokinesia and on days 1, 7, 14 and 25 after the treatment was terminated. Urine was collected once in the baseline period, and on days 4, 10, 25, 32, 56, 75, 100, 112, and 120 of hypokinesia, and on days 4 and 8 of readaptation. Activity of the cholinergic system was estimated on the basis of activity of acetylcholinesterases in erythrocytes, nonspecific cholinesterases measured spectrophotometrically in blood plasma, and by concentration of acetylcholine in whole blood. Activity of the sympathetic adrenal system was estimated on the basis of measurements of blood concentration of epinephrine, norepinephrine; and urine concentrations of these same hormones, plus dopamine, metanephrine, and normetanephrine. All substances were measured in both bound and free forms. Renal excretion of vanillylmandelic and homovanillic acids was also measured. Functioning of the sympathetic adrenal system was assessed on the basis of the relative synthesis and metabolism of catecholamines.

All baseline measurements were within normal limits. During hypokinesia, epinephrine and acetylcholine in the blood were elevated, with acetylcholine at a maximum on days 28, 94 and 112, and epinephrine on days 28 and 52. Blood concentration of norepinephrine was lower than baseline throughout the treatment. Activity of acetylcholine esterases was elevated only on days 92 and 112 of hypokinesia. The authors attribute these results to pronounced activation of the cholinergic blood system on days 28 and in the period starting on day 92. At the same time, excretion of epinephrine, metanephrine, vanillylmandelic and homovanillic acids increased during hypokinesia, while binding of active forms of epinephrine decreased. Methylation (metanephrine/epinephrine) and deamination (vanillylmandelic acid/metanephrine+normetanephrine) increased sharply during hypokinesia. However, the level of free epinephrine was high only on days 52-75 of the treatment, resulting in an increase in the epinephrine/norepinephrine ratio characteristic of a stress response. In the second half of the treatment period, these biochemical changes led to development of neurotic asthenia, a sign of autonomic vascular dysfunction. The activity of the mediator link of the sympathetic adrenal system decreased significantly during hypokinesia. Renal excretion of norepinephrine, dopamine and normetanephrine decreased progressively during the treatment. Synthesis of norepinephrine and dopamine decreased. Synthesis of methylation and deamination of norepinephrine were elevated, while inactivation of dopamine (homovanillic acid/dopamine) decreased compared to baseline. As a result of these changes, body levels of

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norepinephrine and dopamine decreased. When the subjects resumed normal motor activity, blood concentration of epinephrine, norepinephrine, acetylcholine, acetylcholine esterase, and nonspecific cholinesterase increased, as did renal excretion of epinephrine, norepinephrine, dopamine, DOPA, metanephrine, normetanephrine, homovanillic and vanillylmandelic acids. There was also an increase in relative metabolic activity. After return to normal conditions there was an overall activation of the neurohumoral systems with clear predominance of the mediator link of the sympathetic adrenal system.

Table: Renal excretion of catecholamines and their metabolites during hypokinesia with head-down tilt

Figure 1: Concentration of acetylcholine esterases, epinephrine and norepinephrine during hypokinesia with head-down tilt

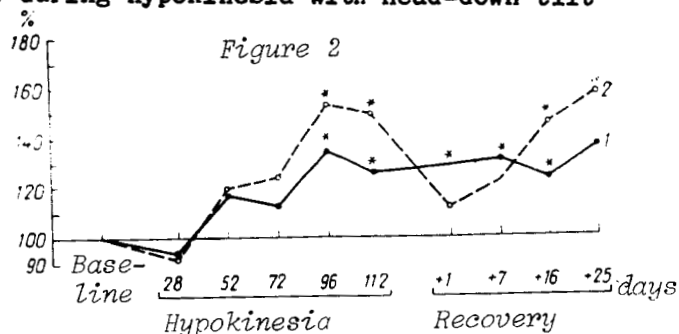


Figure 2: Change in activity of acetylcholine esterases of erythrocytes (1) and nonspecific choline esterases in blood plasma (2) during hypokinesia with head-down tilt (in % of mean)

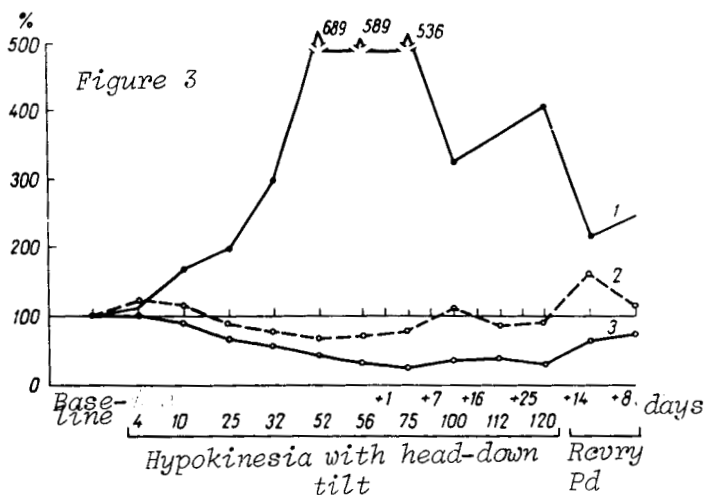


Figure 3: Parameters indicative of relative activity of catecholamine metabolism during hypokinesia with head-down tilt (in urine, in % of mean baseline data. 1 - epinephrine/norepinephrine; 2 - norepinephrine/dopamine; 3- dopamine/DOPA.



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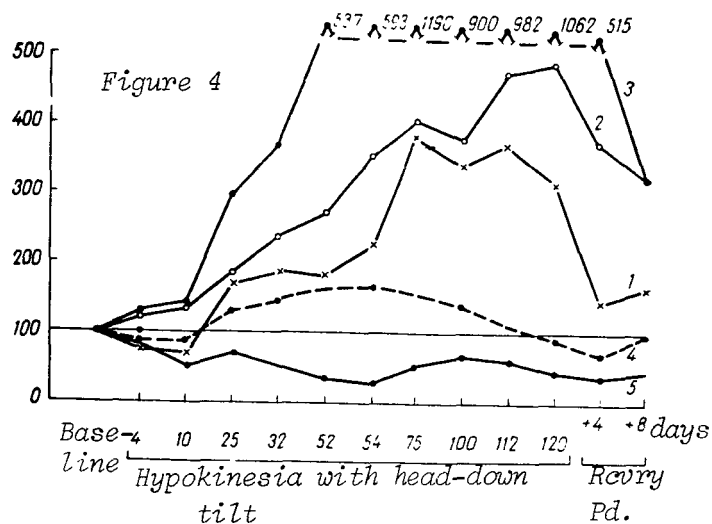


Figure 4: Parameters indicative of relative activity of catecholamine metabolism process during hypokinesia (in urine; in % of mean baseline data) 1 - vanillylmandelic acid/epinephrine+norepinephrine; 2 - vanillylmandelic acid/metanephrine+normetanephrine; 3 - metanephrine/epinephrine; 4 - normetanephrine/norepinephrine; 5- homovanillic acid/2epinephrine.

P439(10/87) Noskov VB, Katkov VYe, Afonin BV, Chestukhin VV, Sukhanov YuV.  
**Central venous pressure and hormonal regulation of fluid shifts due to head-down tilt.**

Fiziologiya Cheloveka.

12(5): 810 - 815; 1986.

[13 references; 9 in English]

Endocrinology, Hormonal Regulation; Body Fluids, Fluid Shifts;

Cardiovascular and Respiratory Systems, Central Venous Pressure

Humans, Males

Head-down Tilt; Diuresis

**Abstract:** This experiment exposed 8 healthy males, aged 30-43 with similar heights and weights, to 2 experimental treatments. In the first condition, all subjects spent 5 hours in a head-down position of  $-15^{\circ}$ ; in the second they were exposed to the same treatment but were given 80 mg of the diuretic furosemide immediately after assuming the head-down position. For 3 days before and during the treatments, subjects consumed a standard diet and a fixed amount of water containing 158-164 mequiv. sodium, 50-66 mequiv. potassium, 12-17 mequiv. calcium, and 1000 ml fluid per day. Treatments began at 9-10 in the morning; after a teflon catheter had been implanted in the right auricle. In a session subjects were weighed, blood was taken, and then subjects were placed in head-down position on a tilt table. Pressure was measured in the right auricle using a Statham electromanometer. Blood for biochemical analysis was taken 2 and 5 hours after the head-down position had been assumed, while blood for study of pH balance was taken every hour. All urine was collected during the treatment, and the bladder was emptied after treatment terminated. Plasma concentrations of angiotensin-1, ACTH, and antidiuretic hormone were measured. Renin activity was determined by radioimmune assay. Sodium and potassium concentrations in blood serum and urine were determined using flame photometry. Concentrations of calcium, magnesium, chlorine, phosphorus, creatinine, and hemoglobin, urea were also measured. Quantity of erythrocytes, hematocrit, and total blood protein were also determined. Indicators of pH balance and gaseous composition of the blood were computed.

In the first condition, subjects experienced typical symptoms associated with head-down tilt, facial edema, hyperemia, etc., accompanied by diuresis and electrolytuesis, and a tendency for aldosterone concentration and renin activity to decrease in blood plasma. In the second condition, the use of the diuretic enhanced (by a factor of 6) the diuretic effect of head-down tilt. Renal excretion of electrolytes was also increased, to the greatest extent for sodium and chlorine (by factors of 4.4 and 4.6, respectively). These effects were accompanied by weight loss, and decrease in circulating blood volume (as indicated by changes in hematocrit, number of erythrocytes, hemoglobin concentration, and total blood protein.) The authors calculate the decrease in circulating blood to be  $3.5 \pm 0.9\%$  in the first condition and  $16.0 \pm 0.8\%$  in the second.

Under both conditions, there was a sharp increase in central venous pressure during the first 15 minutes of head-down tilt (by 29 and 37% respectively) compared to horizontal position, followed by a decrease almost to baseline within an hour. In the first condition (without the diuretic), this value increased only slightly during the next 4 hours,

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remaining essentially at baseline. In the second condition, pressure continued to decrease and by the 5th hour was equal to 44% of baseline. These effects were accompanied by doubling of concentration of antidiuretic hormone, and large increases in angiotensin-1, renin activity, and ACTH concentration. Aldosterone concentration tended to increase in the second condition, while it had decreased in the first. Only insignificant fluctuations in pH balance were observed in the second condition. After termination of the treatment, rate of renal excretion of sodium was lower in the second condition than in the first. The authors attribute the increases in renin activity and concentrations of ACTH and antidiuretic hormone in the second condition as a response to hemoconcentration, while the drop in sodium level is interpreted as a physiological defense against circulatory collapse. All subjects were able to tolerate a 20-minute orthostatic test after treatment termination in the first condition; none were able to do so in the second condition.

Table 1. Renal excretion of fluid, electrolytes, creatinine and urea during hypokinesia with head-down tilt (A) and throughout the whole day (B) in the first and second experimental conditions

Table 2: Parameters of pH balance and oxidative metabolism in blood during hypokinesia with head-down tilt

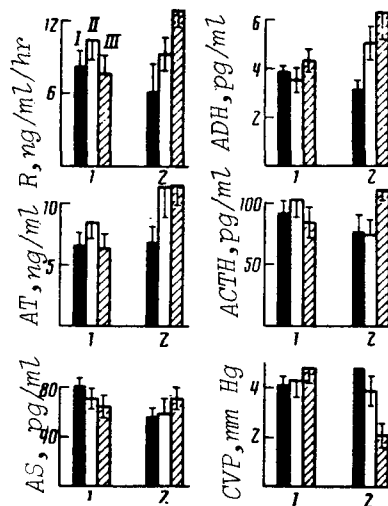


Figure 1: Concentration of hormones in plasma

R - renin activity in blood plasma ng/mL/hr.; AT - angiotensin-1, ng/mL; AS - aldosterone, pg/mL; ADH - antidiuretic hormone, pg/mL; ACTH - adrenocorticotrophic hormone, pg/mL; CVP - central venous pressure, mm Hg. I - baseline; II - 2nd hour of head-down tilt; III - 5th hour of head-down tile. 1, 2 - first and second condition, respectively.

Figure 2: Changes over time in central venous pressure during hypokinesia with head-down tilt in the first and second condition

## ENZYMOLGY

### PAPERS:

P431(10/87)\* Vlasov VD, Dlusskaya IG, Krashutskiy VV, Domnikova AA.  
**Activity of proteolytic enzymes in the blood serum of individuals in a hypoxic environment.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 88-90; 1986.

[15 references; 7 in English]

Enzymology, Proteolytic Enzymes; Neurophysiology, Parasympathetic Nervous System

Humans, Males

Hypoxia, Hypobaria

**Abstract:** Three experiments studied changes in activity of proteolytic and certain other enzymes in the blood of healthy males, aged 19-21, who had spent time in a hypoxic environment with depressed barometric pressure. In the first experiment, 6 subjects spent 4-6 hours (between 10:00 and 18:00) in a barochamber with pressure and oxygen equivalent of 2550-3000 m. Apparently, 4 subjects underwent this procedure twice, and 2 once. After exposure subjects ate and slept. Blood was taken the next morning on an empty stomach. In the second experiment 12 individuals who had never before undergone hypoxia, were exposed for 30 minutes in the morning to an altitude equivalent to 5000 m in the barochamber. Blood was taken 1 hour after this treatment (4 hours after breakfast). Heart rate was also recorded continuously for these subjects beginning before they entered the barochamber. Blood for baseline comparison was taken on an empty stomach 1-2 days before the experiment began. In the third experiment, blood from 19 subjects not exposed to any treatment was also studied. Blood parameters measured included activity of trypsin, trypsin inhibitor, alpha-amylase, cholesterol esterase, lactate dehydrogenases, and gamma-glutamyltransferase.

In the first experiment exposure to hypoxia was associated with significant increases in trypsin and trypsin inhibitor activity. No other changes were observed. In this experiment, lactate dehydrogenase activity increased, as well as trypsin activity, but the increase in trypsin inhibitor was not significant. In the second experiment an increase in trypsin activity after exposure to the barochamber was inversely correlated with increase in heart rate during exposure. The authors attribute these results to increased exocrine activity of the pancreas, which in turn depends directly on the activity of the parasympathetic nervous system. Thus, activity of the parasympathetic system, as well as of the sympathetic, appears to increase under hypoxia.

Table: Concentration of enzymes in blood serum of individuals exposed to hypoxia

Figure: Inverse correlation between increase in heart rate during a hypoxic barochamber stress test and changes in trypsin-like activity in blood serum in the second experiment

## HABITABILITY AND ENVIRONMENT EFFECTS

### PAPERS:

P427(10/87)\* Popov IG, Blodavets VV, Chizhov SV, Sinyak YuYe, Shikina MI, Vinogradova LA, Kolesina NB.

#### Investigation of the causes of the formation of hydrogen sulfide in reclaimed water.

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 75-77; 1986.

[3 references; none in English]

Habitability and Environment Effects; Life Support Systems, Reclaimed Water  
Microbiology, Microflora  
Hydrogen Sulfide

**Abstract:** This paper describes an investigation of the causes of the appearance of hydrogen sulfide in water regenerated from condensed atmospheric water in a closed life support system involving human beings (number of people not specified, length of residence not specified). An odor of hydrogen sulfide was [apparently] discovered after the regeneration apparatus had been taken out of operation and stored for 6 months or a year and then put back into operation. At this point a quantitative evaluation and identification of the species of the microflora in water samples was undertaken. In addition, in order to study the capacity of the microorganisms to form hydrogen sulfide in the presence of inorganic sulfurous compounds, pure cultures were inoculated in meat peptone agar with the addition of 1% thiosulfate, and sampled under constant temperature (37°C) for 24-48 hours in the presence of hydrogen sulfide paper, which turns black if the bacteria produce hydrogen sulfate. It was determined that the odor arose after the system had stopped functioning and as a result of long-term storage (more than 6 months) of volumes of drinking water. The quantity of hydrogen sulfide in the water was 1-2 mg/l. The odor was localized in the apparatus for mineralizing the reclaimed water, which contained calcium sulfide and magnesium. These minerals could be the source of sulfurous compounds, which could form hydrogen sulfide if the water contained sulfate reducing microorganisms. Characteristic microorganisms in the regenerated water included gram-positive cocci, oxidazopositive gram-negative bacteria, and nonfermenting bacteria. Microorganism species composition in those points of the system where the odor of hydrogen sulfide was noticeable were no different from those areas where the odor was absent; however, the number of microorganisms was typically higher in the presence of the odor. The most stable bacteria in water characterized by odor and which had been stored for long periods were Acinebacter Moraxella and Citrobacter fruendii. The following pure cultures were studied for their ability to produce hydrogen sulfide with and without thiosulfate: 7 Aeromonas hydrophyla, 34 Alcaligenes faecalis, 6 Citrobacter fruendii, 48 Micrococcus luteus, 7 Staphylococcus faecalis\*, 9 spore aerobes and 5 E. coli\*. [Those marked with \* were included as controls, they are not present in reclaimed water.] Without thiosulfate, only one of the species, Micrococcus luteus, exhibited a very slight tendency to produce hydrogen sulfide. When thiosulfate was added, all cultures, except some lines of aerobes, produced hydrogen sulfide. The organism with greatest tendency to produce hydrogen sulfide (100%) was E. coli; while Str. faecalis and Citrobacter fruendi showed the least tendency (10-20%). Thus, some of the organisms in regenerated water, while not

## HABITABILITY AND ENVIRONMENT EFFECTS

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ordinarily sulfur reducers, can produce hydrogen sulfide in the presence of inorganic sulfurs such as  $\text{CaSO}_4$  and  $\text{MgSO}_4$  which are found in the mineralization units. This is likely to occur only during sustained interruptions of the functioning of a regeneration system and long-term storage. Possible ways to avoid this problem would include elimination of sulfurous and sulfate-containing compounds in the water reclamation system, increased attempts to minimize growth of bacteria, and use of special sulfur reducing filters for the water.

## HEMATOLOGY

(See also: Radiobiology: P432)

### PAPERS:

P409(10/87)\* Kuznetsova IV.

**[A study of the] state of the hemostasis system in air traffic controllers**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 19-23; 1986.

[14 references; none in English]

Hematology, Hemostasis

Humans, Air Traffic Controllers

Human Performance, Workload

**Abstract:** Subjects of this experiment were 67 air traffic controllers at a major airport, aged 23-67, who had worked in this profession for 5-23 years. Subjects were studied in summer and winter; air traffic was more than twice as heavy in the former period. At each season, parameters were measured on controllers' days off, immediately before going on duty, and immediately afterwards. The following tests were performed on subjects' blood at each period: 1) recalcification time of plasma (using the method of Bergerhof and Roka); 2) concentration of fibrinogen (Bidwell); 3) fibrinolytic activity of whole blood (Kotovshikova and Kuznik); 4) recording of the process of coagulation of plasma citrate using an N-334 coagulograph to evaluate such parameters as start of coagulation ( $T_1$ ), completion of coagulation ( $T_2$ ), and time required for coagulation ( $T$ ); 5) measurement of elastic properties of clots in plasma citrate using a hemocoagulograph to record reaction time ( $R$ ), time to form clots ( $K$ ), coagulation constant ( $R+K$ ), maximum amplitude ( $MA$ ), elasticity of a clot ( $E$ ), and thromboelastic index ( $I$ ). When coagulation was measured after the completion of the working day, there was no difference between winter (light traffic) and summer (heavy traffic) in the proportions of subjects showing normal, hypo- and hyper coagulation. However, on days off and before the beginning of the work shift, substantially more controllers showed normal coagulative properties in winter than in summer. More than three times as many subjects had hypocoagulative blood at these measurement points during the summer as did during the winter. During the period of relatively light work load, the proportion of subjects showing both hypo- and hypercoagulation increased considerably after the work shift, to a greater extent for hypocoagulation. During heavy workload, after the working day the proportion of subjects with hypercoagulative blood decreased by 23%, while the number of subjects with hypocoagulative blood increased by 37%.

**Table:** Value of certain parameters of the hemostasis systems in air traffic controllers during the winter and summer

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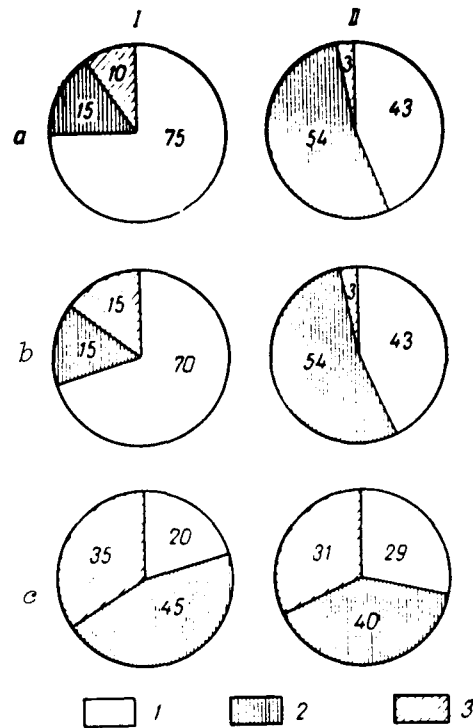


Figure 1. Comparison of the state of the hemostasis system on day off (a), before the beginning of a work shift (b), and after completion of a work shift (c) in air traffic controllers in the winter (I) and summer (II) (in % of total number of subjects). 1 - normal coagulation; 2 - hypocoagulation; 3 - hypercoagulation.

Figure 2. Changes in certain parameters of the hemostasis system in air traffic controllers after completion of a work shift

Figure 3. Certain parameters of the hemostasis system in the summer after completion of a work shift by air traffic controllers

Figure 4. Thromboelastogram for subject Ya.



P443(10/87) Meyerson FZ, Frolov BA, Stadnikov AA.

**Characteristics of the megakaryocyte-thrombocyte system in mice experiencing immobilization stress.**

Patologicheskaya Fiziologiya i Eksperimental'naya Terapiya.

1986(4): 30-35.

[18 references; 3 in English]

Hematology, Megakaryocyte-Thrombocyte System; Morphology and Cytology  
Mice  
Immobilization Stress

**Abstract:** Subjects in this experiment were hybrid mice exposed to immobilization stress lasting 6 hours. Dependent variables included time for blood to clot and number of thrombocytes contained in it. Ultrastructure of thrombocytes was studied with an electron microscope. Tolerance of exogenous thrombin was determined by injecting animals with human thrombin and noting their survival rate. The number of megakaryocytes in bone marrow was determined, and measurements were made of cytoplasm and nuclei. Serotonin concentration in spleen tissue was determined. Measurements were apparently made in a baseline period, after 5 and 30 minutes and 6 hours of immobilization, and 24, 72, and 120 hours after immobilization termination.

Immobilization stress led to fluctuations in clotting time and number of thrombocytes, with two periods (immediately after stress and 72-120 hours after stress termination) of hypercoagulation. The first period was accompanied by a decrease in thrombocytes and the second by an increase in thrombocytes over control level (Table 1). The significance of these fluctuations can be understood by considering tolerance for exogenous thrombin. Survival rate was 70% for nonimmobilized animals, 55% for those injected 72 hours after immobilization and only 29% for those injected after 120 hours. The authors describe the first hypercoagulation period as resulting from mobilization of the sympathetic-adrenal system; the decrease in the quantity of thrombocytes is evidently associated with an increase in their aggregation activity. The rapidly following period of normalization is associated with the activity of an anti-coagulation mechanism; however, this does not mean that hemostasis has been normalized. The stress treatment is followed by the development of thrombohemorrhagic syndrome, triggered by disruption of the microcirculation component of the stress response. The mechanism for the development of the second hypercoagulation period has not been uniquely determined. Changes in megakaryocytes in the marrow and spleen during and after stress are presented in Table 3. This data indicates that the second period of hypercoagulation in response to immobilization stress is accompanied by the activation of megakaryopoiesis and thrombocytopoiesis. However, there are a number of questions still to be answered. The first concerns the reasons for the lack of correspondence between the sharp growth in number of megakaryocytes (increase by a factor of 40 in the spleen) and the relatively moderate increase in thrombocytes in the blood. One possible reason for this is that newly formed thrombocytes are destroyed within the spleen. This explanation is strengthened by the increased level of splenic serotonin (the source of which is thrombocytes) 120 hours after stress termination. The next question concerns whether the increased number of thrombocytes is accompanied by a change in their properties, since the second period of coagulation is accompanied by a normal level of blood platelets. Such

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changes were found to occur; in particular, accompanying the second hypercoagulation period 72 hours after stress termination, the volume of blood platelets increased, as did the number of alpha granules which contained coagulation factors. There was also a 5-fold increase in the microtubule-organelles which activate prothrombin and are the site of  $\text{Ca}^{2+}$  localization. The third question relates to the significance of the identified activation of extramedullary megakaryopoiesis and erythropoiesis in stress. The authors postulate that this is an adaptive response to prevent and/or compensate for excessive blood loss. However, this response would also increase the danger of thrombosis. Since the immune system limits extramedullary hemopoiesis and stress is known to disrupt this system, the authors tentatively postulate this as the source of the effects demonstrated here.

Table 1: The effects of immobilization on clotting of blood and number of thrombocytes

Parameter	Control	Immobilization			Time after immobilization		
		5 min	30 min	6 hr	24 hr	72 hr	120 hr
Time to clot of whole blood, sec.	149.7 (11)	111.4* (9)	121.7 (6)	140.7 (7)	159.9 (13)	107.4* (7)	116.2* (11)
Thrombocytes $10^6/l$	737 (14)	595* (6)	502* (7)	606* (13)	582* (17)	798 (17)	1040* (19)

Here, and in Tables 2-4, numbers in parentheses refer to number of observations. \* designates parameters differing significantly ( $P < 0.05$ ) from control values.

Table 2: Effect of immobilization stress on tolerance of mice for exogenous thrombin

Condition	Reaction		Chi <sup>2</sup>	P
	Died	Survived		
Control (23)	30.4%	69.6%	--	
72 hrs after stress (20)	45.0%	55.0%	0.97	>0.05
120 hrs after stress (21)	71.4%	28.6%	28.6	< 0.05

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Table 3: Concentration of megakaryocytes in bone marrow and spleen of animals at various intervals after immobilization

Parameter	Control	Interval after immobilization			
		24 hours	48 hours	72 hours	120 hours
Red Bone Marrow					
Quantity of megakaryocytes %:					
in suspension	2.7 (8)	3.0 (6)	3.1 (6)	3.2 (6)	3.1 (6)
in cross section	1.20 (5)	1.27 (5)	0.82 (5)	2.36*(5)	2.24*(5)
Size of nuclei, um	12.5	11.2	9.2*	10.2*	19.9*
Cytoplasm area, um	18.1	17.8	13.4*	16.4	28.2*
Spleen					
Quantity of megakaryocytes %:					
in suspension	0.14(5)	0.17(6)	0.72*(5)	5.02*(5)	1.61*(5)
Size of nuclei, um	8.2	9.9*	13.0*	11.9*	11.5*
Cytoplasm area, um	14.6	17.1*	18.1*	22.3*	19.9*

Table 4: Ultrastructure of thrombocytes at various intervals after immobilization (n=5)

Parameter	Control	Condition	
		72 hours after immobilization	120 hours after immobilization
Size of thrombocytes, um	1.33	1.71*	1.45
Number of alpha-granules per thrombocyte	3.11	5.08*	5.93*
Size of alpha-granules, nm	205.0	298.55*	300.10*
Size of microtubules, nm	34.18	176.04*	194.36*

P449(10/87) Kononov SV.

**Adaptation of the rheological characteristics of blood to the effects of maximal physical exertion.**

Teoriya i Praktika Fizicheskoy Kul'tury.

1986(8): 54-55.

[15 references; 4 in English]

Affiliation: Orenburg Medical Institute

Hematology, Rheological Characteristics of Blood; Adaptation

Humans, Males, Athletes

Physical Exercise, Maximal

**Abstract:** Twenty-nine males, aged 22-30, participated in this experiment. Of these, 13 were soccer players and 16 were non-athletes. Dependent variables were apparently measured before and after maximal exercise. The clotting capacity of erythrocytes was determined by a method based on the optical density of blood samples before clotting began and after it was completed. A high percentage change in optical density is supposedly associated with high clotting capacity. A hematocrit centrifuge was used to measure hematocrit. Subjects performed graded exercise on a bicycle ergometer. During the first stage of the experiment, work on the ergometer equalled 1.5 W/kg body weight; during the second it was 3 W/kg; during the third it was 4 W/kg. In the last stage, subjects continued to pedal until they were no longer able to do so under competitive motivation. Before exercise, both clotting capacity and hematocrit were lower in the athletes than the non-athletes. Although these parameters increased in both groups after exercise, this increase was considerably greater in the non-athletes. Thus, the athletes showed better adaptation to the effects of exercise on rheological blood parameters than non-athletes. The authors state that blood rheology is one of the factors determining work capacity during strenuous physical exertion.

**Table: Clotting capacity and hematocrit in athletes and non-athletes before and after maximal physical exercise**

Parameter	Before or After Exercise	Control	Athletes	p
Clotting capacity, % optical density	Before	0.05	0.03	< 0.001
	After	0.09	0.04	< 0.001
Hematocrit, %	Before	45.1	42.7	< 0.05
	After	48.5	45.9	< 0.05

## HUMAN PERFORMANCE

(See also: Biological Rhythms: P408; Hematology: P409; Neurophysiology: P423)

### PAPER:

P410(10/87)\* Makarevich OF.

**Tolerance of frustration as a factor influencing the reliability of an [human] operator's work.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 24-26; 1986.

[6 references; none in English]

Human Performance, Reliability

Humans, Air Traffic Controllers

Psychology, Frustration, Tolerance

**Abstract:** The goal of this study was identification of the relationship between the reliability of an air traffic controller's performance and his response to frustration. Subjects were 59 controllers, aged 28-42. The general performance level of each controller was rated by 5 "experts," supervisors and co-workers. On the basis of mean ratings, two groups of subjects were identified, with 15 members in each. Group 1 was composed of superior workers and group 2 of inferior performers. A Rosenzweig frustration test was given to each subject. When this test was applied to air traffic control performance, 3 reaction tendencies were identified in the subjects: 1) intrapunitive, tendency to blame oneself for poor performance; 2) extrapunitive, tendency to blame co-workers, supervisors or instrumentation for performance problems; 3) nonpunitive, considered the most effective response in situations of conflict. In addition, response to this test could be scored on 3 characteristic reaction types. Predominance of reactions of the obstacle-dominant type in a subject's response is supposed to reflect low tolerance of frustration. Prevalence of ego-dominant reactions is supposed to be an indicator of ego strength. Solution-oriented responses are considered to be the most appropriate. Results indicated that superior controllers showed a high tolerance of frustration as revealed by low scores on the obstacle-dominant factor, with prevalence of solution-oriented response. Responses of these subjects showed a prevalence of nonpunitive tendencies. Inferior controllers were significantly more likely to give obstacle dominant and extrapunitive responses.

**Table.** Differences in type of reaction to frustration between air traffic controllers in groups 1 and 2

**Figure.** Proportions of responses of various types and tendencies in representative air traffic controllers in groups 1 and 2.

MONOGRAPH:

M100(10/87)\* Matyukhin VA, Krivoshechekov SG, Demin DV.

**Physiology of human dislocation and watch\* work.**

Novosibirsk: Nauka (Sibirskoye Otdeleniye); 1986.

[196 pages]

Affiliation: [Book] USSR Academy of Sciences (Siberian Division); USSR Academy of Medicine (Siberian Division)

\*We have not been able to find a satisfactory translation of the word here rendered as "watch." The dictionary definition of the Russian word "vakht" is: a group of people travelling to a specific locality to perform shift work for a specified period of time.

Annotation: This monograph presents the major tenets of a new division of human physiology -- physiology and chrono-ecology of geographic dislocation, associated with changes in environmental, climatic, social, and job performance conditions. The monograph includes the first taxonomy of types of dislocation and the stress they place on physiological systems. Methodological and structural principles for studying physiology during various stages of adaptive and maladaptive processes are considered. The author describes quantitative methods (including those using computers) for evaluating environmental factors. Techniques for predicting the severity of the demands placed on adaptive processes in specific instances of dislocation are also described. This book is intended for scientists working in the area of ergonomics, industrial hygiene, work physiology, human ecology, and biological rhythms.

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## IMMUNOLOGY

### PAPERS:

P450(10/87) Apanasen'ko GL, Nedopryadko DM.

#### **The role of autoimmune responses in the recovery period after strenuous physical exercise.**

Teoriya i Praktika Fizicheskoy Kul'tury.

1986(8): 48-51.

[29 references; 5 in English]

Affiliation: A.A. Bogomolets Medical Institute, Kiev

Immunology, Autoimmune Responses

Humans, Athletes

Adaptation, Physical Exercise

**Abstract:** Measurements were made on 106 individuals [presumably athletes] adapted (trained) to strenuous physical activity and 84 nonathletes. Athletes were studied during the course of their normal training/competition cycle, and before and after graded exercise to exhaustion on a bicycle ergometer. In addition, 60 rabbits trained to run on a treadmill were studied. Parameters indicative of immunological function which were measured in vitro included autoantibody complement-binding in response to myocardial antigen (obtained from healthy individuals killed in accidents) and antiideotypic serum IgE, autohemolysins, autoimmune degranulation of basophilic leukocytes and mast cells, T-helpers and T-suppressors, T-suppressors regulating autoimmune processes, inhibition of leukocyte migration in helium, adhesion and immunoagglutination of A-cells stimulated by tissue antigens and cellular subfractions of the cardiac muscle. Lactate, succinate, malate, glycerol phosphate, glucose-6-phosphate,  $\text{NAD}^+\text{H}_2$ , basic and acid phosphatase, RNA, histidine, acetylcholine, acetylcholinesterase and nonspecific esterase activity, histamine, histaminapexia, and histidine decarboxylase activity were studied in blood cells, cellular suspensions, and cellular supernatants obtained after contact with antigens.

Results on humans and animals showed that strenuous physical exercise led to increased immune responses of all types stimulated by tissue antigens of the heart, liver, skeletal muscles and leukocytic antigen. The degree of increase was a joint function of previous conditioning and the nature of the exercise. In rabbits, cardiogenic autoimmune reactions increased under fatigue and especially exhaustion, and were inversely correlated with indicators of general immunological sensitivity. In humans, highly trained athletes showed less intense autoimmune reactions after exercise than less well-trained and untrained counterparts, indicating more efficient hormonal and metabolic regulation. The experiment demonstrated two ways to stimulate protein synthesis via the immune system: 1) induction of trophotropic substances (e.g., serotonin, histamine) in degranulation of mast cells and basophilic leukocytes resulting from "autoantigen-autoantibody" responses on the surface of their membranes, and also the secretion of acetylcholine as a consequence of local hemolysis of erythrocytes through operation of immune mechanisms and mediatory activity of immunocompetent cells; 2) output of specific inductors of enzymatic

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synthesis of lymphokines. The increase in degranulation of basophils after exercise was greater in trained than untrained subjects; addition of myocardial antigens increased the response in both types of subjects, but to a more marked degree in the untrained. A similar pattern was noted in the case of local hemolysis of plaque-forming blood cells. Stimulation of the immunocompetent cells with a cardiogenic mediator after exercise increased cellular response in athletes. Lymphokine acting specifically on cellular cooperation and immune response stimulated the synthesis of adaptive enzymes under the same circumstances.

Table: Myocardial autoimmune reactions before and after anaerobic-glycolytic physical exercise to the point of exhaustion in untrained individuals (n=18) and athletes adapted to physical exertion

Subject Group	Time of Measurement	Autoimmune response parameters with myocardial antibody					
		1*	2	3	4	5	6
Untrained	Before	6.52	2.7	4.9	2.21	2.6	43.25
	Exercise						
	After	9.85	7.5	16.0	1.38	8.9	84.13
	Exercise	p>0.05	p<0.001	p<0.001	p<0.001	p<0.001	p<0.001
Trained	Before	3.58	2.6	4.4	2.11	3.1	42.75
	Exercise						
	After	5.27	3.4	7.2	1.92	4.0	52.75
	Exercise	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05	p>0.05
		p <sub>1</sub> <0.01	p <sub>1</sub> >0.05	p <sub>1</sub> >0.05	p <sub>1</sub> >0.05	p <sub>1</sub> >0.05	p <sub>1</sub> >0.05
		p <sub>2</sub> <0.01	p <sub>2</sub> <0.01	p <sub>2</sub> <0.01	p <sub>2</sub> <0.01	p <sub>2</sub> <0.001	p <sub>2</sub> <0.01

\* 1-local hemolysis of plaque-forming cells, %; 2 - complement consumption reaction, arbitrary units; 3 - inhibition of hemoagglutination, titers; 4 - inhibition of leukocyte migration; 5 - complement consumption response with anti-IgE, units; 6 - immune complexes, units.

p - significance of difference before and after exercise;

p<sub>1</sub> - significance of difference between untrained and trained individuals before exercise;

p<sub>2</sub> - significance of difference between untrained and trained individuals after exercise.

Figure 1. Spontaneous and stimulated (by myocardial antigen) basophil degranulation reaction before and after maximal physical exercise.

Figure 2. Local hemolysis of plaque-forming blood cells (spontaneous and stimulated by myocardial antigen) before and after maximal physical exercise

Figure 3. Local hemolysis of plaque-forming blood cells stimulated by myocardial antigen and mediator components of lymphocytes in athletes after physical exercise involving speed tolerance

Figure 4. Stimulated enzymatic activity of neutrophils and lymphocytes before and after exercise with mediator component of lymphocytes isolated after their sensitization by myocardial antigen.

## LIFE SUPPORT SYSTEMS

(See also: Habitability and Environment Effects: P427; Musculoskeletal System: P426)

### PAPERS:

P429(10/87)\* Drugova NA, Yunusova LS, Shaydorov YuI.

**[Properties of] the formation of a microbial complex in nutrient solutions of higher plants using products of straw mineralization.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 81-85; 1986.

[10 references; 2 in English]

Life Support Systems, CELSS, Microbiology, Microflora  
Botany, Lettuce  
Straw Mineralization Products, Ecotol

**Abstract:** The plant used in this study was "Berlin" lettuce which has a growing season of 28 days and is highly sensitive to changes in cultivation conditions. The lettuce was grown using the subirrigation-aerobic method in a specially developed apparatus. Illumination was continuous at 50 W/m<sup>2</sup> with constant temperature of 21°. The experiment lasted 189 days, 7 consecutive growing periods. There were 3 conditions: I (control) in which a Chesnokov mixture served as the nutritive solution; II in which 26 mg/l ecotol, a dissolved organic substance produced by the microbial decomposition of grain straw, was added to the Chesnokov medium; III in which 73 mg/l ecotol was added. Every week the concentration of ecotol was adjusted to accord with the cited value and the nutritive solution was corrected for the major necessary mineral elements. Microflora accompanying lettuce growth were studied using standard methods. Measurements were made on days 7, 14, 21, and 28 of each growth cycle. Samples were grown in Petri dishes at 30°C for 5-7 days, followed by 2-3 days at room temperature. Standard meat peptide agar was used for determining the overall concentration of microorganisms, while a dense medium with cabbage agar was used for measuring epiphyte flora. Actinomycetes were counted on starch-ammonia agar after 7-14 days and 21 days of incubation, while microscopic fungi were grown on Chapek's medium with boric acid for 7 days. Each sample was duplicated 3 to 5 times. Bacteria were identified for samples grown on all 4 media. Microorganisms were identified to the species level.

The growth cycle of Berlin lettuce was accompanied by a concentration of microorganisms which fluctuated within the range of 10<sup>5</sup>-10<sup>6</sup> cells per 1 ml solution. Toward the end of each cycle, microbial concentration decreased somewhat. Long-term use of Chesnokov solution had a deleterious effect on the development of the plants, which, starting with growth cycle 3 showed nonbacterial necrotic damage, most pronounced in the control plants. In conditions I and II, concentration of microflora determined using incubation on cabbage agar, decreased to 10<sup>4</sup> per 1 ml solution. Yield also decreased. However, starting with the 4th cycle, epiphyte concentration increased sharply, accompanied by a small increase in yield. In cycles 5-7, the quantity of bacteria decreased to the level of cycles 1-3. Similar results were observed when meat peptide agar was used. No differences among conditions were observed. Over the entire experimental period 19

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species of bacteria were observed. During the first cycle, a stable microbial complex was established with gram negative rods of the family Pseudomonas dominant. When ecotol was added to the nutritive medium, fluorescent pseudomonas and spore-forming bacteria were dominant. The concentration of fungi did not change over the course of the experiment, nor were there differences among conditions. Actinomycetes increased gradually in all 3 conditions. The authors state that the results of this experiment support the conclusion that ecotol can be included in the nutritive solutions used within a closed ecological life support system for cultivating plants, since the microbe complex formed during the first few growth cycles remained stable throughout the period studied and the similarity of microbial components remained high for all conditions.

Table: Microflora accompanying the growth of lettuce

Figure 1: The development of bacterial flora in nutritive solutions for lettuce plants

Figure 2: Changes over time in fungi and actinomycetes developing in nutritive solutions for lettuce

**METABOLISM**

(See also: Cardiovascular and Respiratory Systems: M101; Nutrition: P412; Radiobiology: M98)

**PAPERS:**

P413(10/87)\* Smirnov KV, Medkova IL, Zhiznevskaya OV, Bychkov VP, Mosyakina LI, Khokhlova OS.

**Lipid metabolism parameters in men exposed to hypokinesia with head-down tilt, and means of normalizing these parameters.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 34-37; 1986.

[14 references; 3 in English]

Metabolism, Lipids

Humans, Males

Hypokinesia, Head-Down Tilt; Countermeasures, Nutrition, Linoleic, Linolenic Acids

Abstract: In this study 21 males, aged 30-40, underwent 120 days of bed rest with head-down tilt of  $-4.5^{\circ}$ . Subjects were divided into 4 groups: group 1 (n=9), the control group, received no countermeasures; group 2 (n=4) followed a program of physical exercise while undergoing hypokinesia; group 3 (n=4) received vitamin F-99 (containing 250 mg each of linoleic and linolenic acid) 3 times a day during days 72-120 of the treatment; group 4 (n=4) received the combined treatments given to groups 2 and 3. Groups 3 and 4 also received substances normalizing metabolism (not specified) which the authors state do not affect lipid metabolism. Blood was taken for all subjects during a baseline period, on days 28, 49, 72, 92, and 111 of hypokinesia, and on days 7 and 26 of recovery. To determine the level of cholesterol in bile, duodenal sounding was performed on days 20, 67, 90, and 112 of hypokinesia and on days 7 and 20 of recovery. Lipids were extracted from serum and bile and subjected to thin layer chromatography to determine their spectra. Quantitative evaluation of lipid spots was performed, using densitometry, for free cholesterol, cholesterol esters, phospholipid mixtures, and mixtures of free fatty acid. Lipoprotein fractions were determined using paper electrophoresis.

In the blood of the control group, total lipids changed only insignificantly during the treatment. Significant changes were noted in the concentration of total cholesterol attributable to changes in nonester bound fractions. There was a marked increase in concentration of cholesterol esters starting on day 72 and continuing through the recovery period. Triglycerides tended to increase during the initial hypokinesia period and then returned to normal. Level of nonesterized fatty acids decreased sharply. During hypokinesia, the proportion of alpha-lipoprotein fractions was lower than the norm. Subjects in group 2 (exercise only) showed a pattern of results analogous to that of the control group. Subjects in group 3 (nutritional supplement only), like those in groups 1 and 2, displayed increased cholesterol esters on day 72 [Note: supplement not administered until day 72], but this level had returned to baseline by day 92; after termination of the supplement in the recovery period the level of these ethers rose again. This group showed less phospholipemia

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than groups 1 and 2. No statistically significant changes in lipoprotein fractions was observed in group 3. In group 4 (exercise and supplement) hypercholestremia was pronounced until the administration of the supplement, after which it decreased sharply, reaching baseline level. No decrease in phospholipids was observed with this group. Triglycerides tended to increase on day 72, but then decreased. There was less decrease in alpha-lipoproteins in this group than in the others. Study of cholesterol in the bile showed an increase in subjects in all groups.

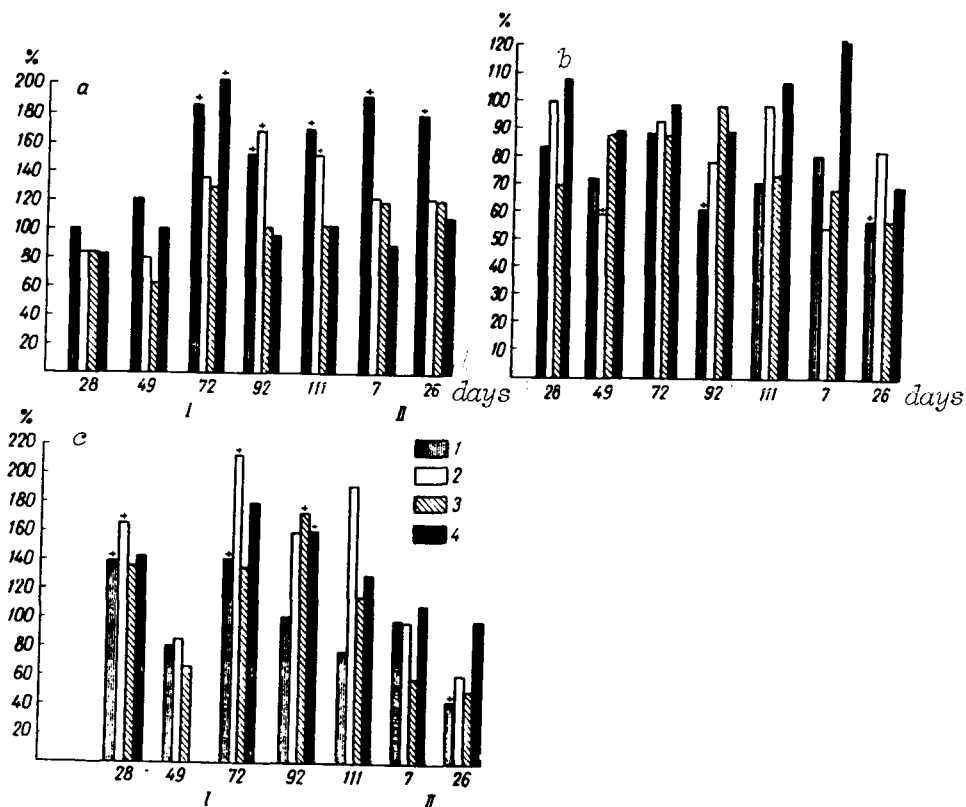


Figure. Concentration of cholesterol ethers (a), phospholipids (b), and triglycerides (c) in blood serum (in % of baseline).

Abscissa: I - hypokinesia; II - recovery period. 1 - 4 refers to groups 1 - 4.

P419(10/87)\* Yershikov SM.

**The effect of hypokinesia on rate of gluconeogenesis in the renal cortex of rats.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 41-44; 1986.

[19 references; 3 in English]

Metabolism, Gluconeogenesis, Renal Cortex

Rats

Psychology, Immobilization, Stress

**Abstract:** Subjects in this experiment were 95 white outbred rats, 45 of which served as controls. All rats received identical diets. Experimental rats were confined in immobilization cages (apparently for varying periods: 1, 3, 7, 15, 30, and 60 days) and were sacrificed. Before sacrifice, the animals were deprived of food for 16-18 hours. The kidneys were removed and rate of gluconeogenesis in sections of the cortex was measured using a modification of the in vitro method of incubation of tissue sections developed by Krebs et al. (reference not provided), using either no substrate or aspartic acid, glutamic acid, pyruvic acid, alpha-ketoglutaric acid, succinic acid, or glycerin as the substrate. Glucose formation from endogenous substrates in the cortical layer of the kidneys of the control group was very slow, but accelerated when tissues were incubated with metabolites of the Krebs series (alpha-ketoglutaric or succinic acids). The most effective glucose source among the other substrates was glutamic acid, while the least effective was glycerin. Changes in gluconeogenesis in experimental rats fluctuated as a function of duration of hypokinesia. In the early stages, a stress reaction was observed, involving increases in rate of gluconeogenesis to all substrates except alanine. This reaction peaked on day 3. By day 7, gluconeogenesis had slowed, and did not differ statistically from control values. At the same time, blood serum glucose was significantly above control level. On day 15 there was a substantial decrease in gluconeogenesis from pyruvic acid; blood serum glucose also decreased. By day 30 subjects had adapted to hypokinesia and albuminolysis and the use of amino acids for energy observed earlier was replaced by relative stabilization of protein structures. Rate of gluconeogenesis from amino acids (excluding alanine) was depressed, while formation of glucose in the presence of alpha-ketoglutaric and succinic acids increased. Serum glucose remained below control level. By day 60, signs of exhaustion of adaptive mechanisms were observed. Rate of glucose formation from glutamic, aspartic acids and from alanine increased. Serum glucose was substantially decreased compared to baseline. The authors note the discrepancies between changes in rate of gluconeogenesis in the kidney and level of glucose in the blood after long periods of immobilization, but offer no explanation.

Table 1: Formation of glucose from various substrates in sections of the renal cortex of rats undergoing hypokinesia of varying duration

Table 2: Concentration of glucose in blood serum of rats which had undergone hypokinesia varying in duration

P430(10/87)\* Krylov YuF, Tigranyan RA.

**Hormonal-metabolic status of humans in the Far North.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 85-88; 1986.

[17 references; 5 in English]

Metabolism; Endocrinology, Hormonal Status; Body Fluids, Fluid-Electrolyte

Homeostasis

Humans, Males

Adaptation, Far North; Physical Exercise

**Abstract:** Venous blood and daily urine were sampled from 10 healthy men, aged 24-25, after a 17-day ski trip in the Far North, with air temperature of  $-32 - -34^{\circ}\text{C}$ . Blood was taken 5 days before the trip, on day 11 of the trip, and day 2 after its completion. Serum, plasma, and urine obtained during the trip were frozen. The following parameters were determined by radioimmune assay: ACTH, hydrocortisone, aldosterone, thyrotropin (TSH), thyroxin ( $\text{T}_4$ ), triiodothyronine ( $\text{T}_3$ ), growth hormone, insulin, prolactin and testosterone in blood, and also renal excretion of hydrocortisone, and aldosterone. Levels of Na and K in blood and urine were determined using atom absorption spectrophotometry; concentration of glucose and triglycerides were determined enzymatically. Results are given in the table below. Results with ACTH and hydrocortisone are interpreted as indicating changes in glucocorticoid metabolism. Decrease in level of blood testosterone confirms earlier results pointing to a stress reaction under these conditions, as does increased concentration of aldosterone, which may be associated with increased reabsorption of NA (decreased renal excretion). Decreased excretion of K and its increased concentration in the blood is associated with physical exercise and increased insulin concentration. Increased growth hormone in the absence of increased glucose, insulin, hydrocortisone, and triglycerides in the blood are associated by the authors with intensified protein synthesis. The authors conclude that these results indicate that a long ski trip in the extreme conditions of the Far North gives rise to a stress reaction to exercise and cold. In addition, these data suggest that the endocrine system plays an active role in the body's adaptive response to the climate and geographical conditions at high latitudes. This is supported by the marked changes in the incretory activity of the adenohypophysis, thyroid, adrenal glands and gonads, and simultaneous changes in fluid-electrolyte homeostasis. The presence of altered relationships among the various components of the anterior lobe of the pituitary and the fact that the changes in fluid electrolyte metabolism are not all in the same direction should also be noted. All this suggests that a complex restructuring occurs in the endocrine system to enable the body to adapt these conditions.

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Table: Concentration in blood of hormones, electrolytes, glucose, and triglycerides and their excretion in participants in a ski trip

Parameter	Before Trip	During Trip	After Trip
<b>Blood</b>			
ACTH, pg/ml	15.62	57.33***	17.02+++
Hydrocortisone, ug%	12.41	12.68	16.55**,++
Aldosterone, pg/ml	22.90	49.80 <sup>1</sup>	33.60*
TSH, u units/ml	1.67	1.76	1.84
T <sub>4</sub> , ug%	7.22	5.35*	5.95
T <sub>3</sub>	142.4	163.5**	119.1*,+++
Growth hormone, ng/ml	1.29	3.77**	1.81+
Insulin, u units/ml	18.79	15.65	16.39
Prolactin, u units/ml	222.1	174.3	172.0
Testosterone, ng%	658.0	447.0***	533.0**
Na m equiv/l	143.87	144.87	145.0
K m equiv/l	3.02	4.43**	4.23
Glucose, mg%	91.87	103.7	107.7
Triglycerides, mg%	115.96	82.26	120.14
<b>Urine</b>			
Hydrocortisone, ug/day	294.0	145.45*	212.25
Aldosterone, ug/day	60.77	52.2	63.05
Na, m equiv/day	490.3	215.4***	373.2**,++
K, m equiv/day	104.8	42.8**	57.3***

\* P < 0.01, \*\* P < 0.01, \*\*\* P < 0.001 significance of difference from parameter value before the trip; + P < 0.05, ++ P < 0.01, +++ P < 0.001, significance of difference from parameter value during trip; <sup>1</sup> individual variability was so great for this parameter during the trip (s.d.=21.35) that none of the comparisons it entered into were statistically significant.



**MICROBIOLOGY:** See Life Support Systems: P429

**MORPHOLOGY AND CYTOLOGY:** See Botany: P437; P441; Cardiovascular and Respiratory Systems: P447; Hematology: P443; Neurophysiology: P420, P424

### **MUSCULOSKELETAL SYSTEM**

(See also: Radiobiology: M98)

#### **PAPERS:**

P426(10/87)\* Makarovskiy VV, Khalangot AF, Shafranskiy YuA, Kryzhanovskaya GF.

**[Evaluation of] the functional status of the musculoskeletal system on the basis of biochemical blood parameters for people living in a closed life support system.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 69-75; 1986.

[18 references; 7 in English]

Musculoskeletal System, Functional Status, Blood Parameters

Humans, Males

Life Support System, Closed, Isolation, CELSS

**Abstract:** In this study 72 healthy men lived for 30 days in hermetically sealed quarters with constant temperature (20-24°C), air flow (0.1-0.3 m/sec), relative humidity (70-80%), concentration of CO<sub>2</sub> (0.3-0.6%), and concentration of O<sub>2</sub> (19-20.8%). [Note it is not made clear how many of the subjects lived together in these quarters.] The men were divided into 3 groups on the basis of age. Members of group 1 (n=16) were 19-21, of group 2 (n=26) 25-43, and of group 3 (n=30) 48-59. Group 3 was further subdivided into two subgroups (n=10 each). Group 3a engaged in a daily exercise program from days 7 - 30 of seclusion; while group 3b did not do so. Venous blood was taken at 8:00-9:00 on an empty stomach periods: before seclusion (period 0), on days 7-8 of seclusion (period 1), on days 14-15 of seclusion (period 2) or days 29-30 (period 3). Blood samples were used to determine activity of creatine phosphokinases (CPK), lactate dehydrogenases (LDH), asparagine aminotransferases (AAT), and alkaline phosphatases (AP), and to measure concentrations of creatinine, calcium and inorganic phosphorus. Commercial serums were used as controls. Baseline values of LDH activity, AP activity (group 2 lower than others), calcium concentration, and inorganic phosphorus concentration differed significantly among age groups. During the course of the 30-day seclusion period, levels of CPK, LDH, AAT and creatinine decreased in members of all groups, although differences were not always statistically significant. Alkaline phosphatase decreased in groups 1 and 2, but showed a non-significant tendency to increase in the older subjects in group 3. Older subjects who exercised showed less decrease in CPK, LDH, and AAT than counterparts who did not exercise.

**Table 1:** Activity of CPK, LDH, AAT, AP and concentration of creatinine, calcium and inorganic phosphorus in the serum of healthy males in the baseline period

**Table 2:** Changes in biochemical parameters of the blood of healthy men living in hermetically sealed quarters

**Table 3:** Correlation coefficients among biochemical parameters in the blood

## MUSCULOSKELETAL SYSTEM

P442(10/87) Rogacheva IV.

**The effect of calcitonin and retabolil on the condition of the femur in rats undergoing hypokinesia.**

Patologicheskaya fiziologiya i eksperimentalnaya terapiya.

1986(4): 53-56.

[7 references; none in English]

Musculoskeletal System, Femur

Rats

Hypokinesia, Amputation, Countermeasures, Calcitonin, Retabolil

**Abstract:** Subjects in this experiment were 150 Wistar rats in which the lower third of the left leg had been amputated to reduce loading on the femur. Animals were divided into 4 groups: group 1 received no further treatment; group 2 received 2 units calcitonin per day, administered subcutaneously; group 3 received 0.2 ml of retabolil?? (described as the most common drugs in the anabolic series) intramuscularly every 10 days; group 4 received both substances in combination. Substances were administered over a 40-day period. In addition to data from group 1, data from the corresponding intact limbs of animals in experimental groups were compared. Animals were sacrificed on days 20, 40, 60 and 100 after amputation, and their femurs isolated. Weight and size of the entire bone, its head and distal epiphysis, as well as density, ash content, and mineral saturation were measured. Lateral measurements were obtained using x-rays of the central portion of the femur.

Size of non-supporting femurs of animals in group 1 had decreased by 10-14% 20 and 40 days after amputation and did not decrease further. Bone volume decreased by 5-8% compared to control. Calcitonin, retabolil or their combination had no effect on the volume of the supporting bone in animals of groups 2-4 during the first 20 days. The 2 drugs administered separately did not retard loss in bone volume in the non-supporting bone; but their combination did. When lateral measurement of the diaphysis was performed, it was found that the width of the cortical layer of the non-supporting femur in frontal projection decreased progressively from 20 to 60 days; this effect was even more noticeable in lateral projection. The width of the medullary cavity changed only slightly in frontal projection, and not at all in lateral. The authors conclude that hypokinesia retards the formation of bone tissue, without increasing resorption through the medullary cavity. Administration of calcitonin for 20 and particularly 40 days led to a decrease in the lateral measurements of the diaphysis in supporting bones, due to decrease in the cortical layer. This leads the authors to hypothesize that calcitonin inhibits resorption of bone tissue by the medullary cavity. The dimensions of non-supporting bones decreased somewhat more than those of supporting bones under the influence of calcitonin. Administration of retabolil alone had no effect on the cross sectional measurement of the diaphysis of either supporting or non-supporting femurs. The combination of the two substances for 20 or 40 days had no effect on the supporting bone, but did inhibit atrophic changes in the cortical layer of non-supporting femur. Bone density of the diaphysis in the non-supporting bone fluctuated, as did mineral saturation, while ash content remained constant. The density of the head of the bone had decreased by 22.4% at 20 days but recovered to 91% of control level at 100 days. Similar changes occurred with respect to mineral saturation in the

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head and epiphysis [See Figure.] Calcitonin increased mineral saturation in the diaphysis and head of the bone (40-day administration only). Retabolil had no effect on the density or mineralization of non-supporting bones. The combined administration of calcitonin and retabolil decreased osteoporosis in the spongy bone of nonsupporting femurs.

The authors conclude that when a limb loses its support function, femur growth is retarded, thickness of the cortical layer decreases, and osteoporosis begins in the spongy structures. Calcitonin and retabolil administered either separately or in combination have no significant effects on the density or mineralization of the cortical layer or spongy structures of limbs which retain their supporting function, but the combined administration of these preparations has a marked prophylactic effect with respect to osteoporosis, preventing the development of atrophic changes in the bone tissue. This can be explained by the fact that retabolil retards the catabolism of bone proteins, while calcitonin decreases demineralization.

Table: The effect of calcitonin and retabolil on the dimensions of the diaphysis of femur bones

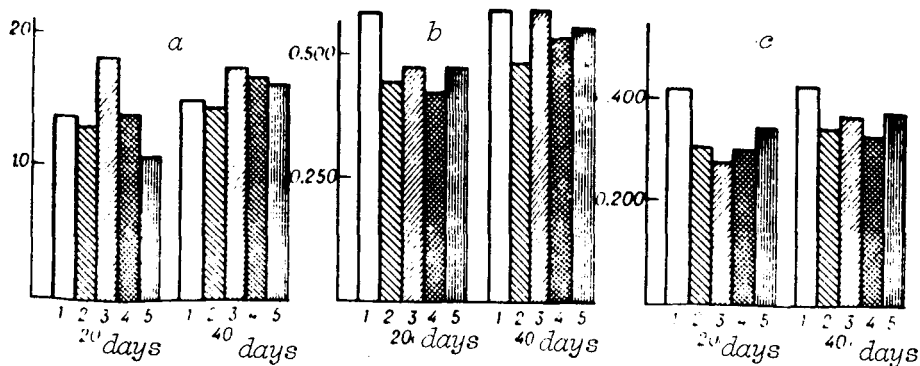


Figure: The effect of calcitonin and retabolil on mineralization of femur bones.  
 1 - control; 2 - "nonsupporting;" 3 - "nonsupporting" + calcitonin; 4 - "nonsupporting" + retabolil; 5 - "nonsupporting" + calcitonin + retabolil.  
 a - diaphysis; b - head; c - distal epiphysis of the femur. Ordinate - mineral saturation (in mg/cm<sup>3</sup>); horizontal - days of experiment.

P446(10/87) Slesarenko NA.

**Structural adaptation of the articular cartilage in fur-bearing animals varying in motor activity.**

Arkhiv Anatomii, Gistologii i Embriologii.

XCI(7): 75-79; 1986.

[5 references; 2 in English]

Affiliation: Department of Animal Anatomy, Veterinary Institute, Moscow.

Musculoskeletal System, Cartilage, Articular; Adaptation

Minks, Sables

Hypodynamia

**Abstract:** This study examined the articular cartilage of the condyles of the femur of 60 sables and minks, aged 6 months to 14 years, which had either been recently captured from the wild or kept under conditions of hypodynamia in cages on a fur ranch. Samples of the distal epiphysis of the femur were prepared for examination with optical, scanning electron, and X-ray microscopes. The subchondral bone layers of the hypodynamic animals were thinner than those of normal animals, testifying to better nutrition and physiological repair of cartilage in the latter. The articular cartilage of young animals living in the wild was thicker than that of older specimens. This testifies to the continuing growth of the skeleton in the former and to the onset of senile atrophy and attenuation of the cartilage regeneration process in the latter. The articular cartilage of young hypodynamic animals was virtually identical in thickness to that of their wild counterparts, while the cartilage of older caged animals was substantially thinner than that of older free-living ones. Wild animals show active proliferation of chondrocytes, while caged animals show increased calcification. Caged animals show thinning of the articular cartilage in the lateral but not the medial layer of the joint. This is associated with the fact that the lateral level is exposed to less loading but greater friction than the medial.

Table 1: Thickness of articular cartilage and its zones on the distal epiphysis of the femur in fur-bearing animals.

Animal	Condi- tions	Thickness of medial condyle				Thickness of lateral condyle			
		Total	Deep Layer	Middle Layer	Surface Layer	Total	Deep Layer	Middle Layer	Surface Layer
Sable	Wild	479	172	170	111	620	189	292	152
	Caged	480	185	185	108	406	135	177	92
Mink	Wild	254	67	154	31.8	274	80	172	21.0
	Caged	226	65	143	13.8	156	43	113	11.0

Figure 1: Distal epiphysis of the femur bone of an adult sable

Figure 2. Zonal differentiation of the articular cartilage of the distal epiphysis

Figure 3. The articular cartilage of the lateral condyle of the distal epiphysis of the femur of adult sables caught in the wild and raised on a ranch.

## NEUROPHYSIOLOGY

(See also: Cardiovascular and Respiratory Systems: M101;  
Endocrinology: P433; Enzymology: P431; Nutrition: P412)

### PAPERS:

P420(10/87)\* Krasnov IB, D'yachkova LN.

**The ultrastructure of the cortex of the cerebellar nodulus in rats flown on the "Kosmos-1511" biosatellite.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 45-47; 1986.

[18 references; 8 in English]

Neurophysiology, Cerebellar Nodulus; Morphology and Cytology, Ultrastructure  
Rats

Space Flight, "Kosmos-1511"

**Abstract:** The authors studied the cerebellar nodulus of 3 rats which had flown for 5 days on the "Kosmos-1511," 5 rats in a synchronous ground experiment and 5 rats in a vivarous control. Animals were sacrificed 6-8 hours after landing, and a fragment of the nodulus taken from the left side was fixed and dehydrated. Ultrafine sections were produced, stained with uranyl acetate and lead citrate, and examined with an electron microscope. The density of synaptic vesicles in the mossy fibers of flight rats was significantly greater than control, which did not differ from each other. In flight rats, the granular cells around the glomerulus showed increased condensation of chromatin along the periphery of the nuclei, and a broader perinuclear space. The number of lamellar elements in the perikaryon was increased, its cistern was broader, and the number of free ribosomes was increased. These results are explained in terms of heightened excitation of terminals of moss fibers and granule cells, reflecting the excitatory state of the otolith hair cells and neurons of the vestibular ganglion produced by reexposure to normal gravity. It is hypothesized that the system composed of the otolith and neurons of the vestibular ganglia increased in sensitivity during exposure to weightlessness.

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Figure: Terminals of mossy fibers in the granular layer of the cortex of the cerebellar nodulus of rats.

Scale: 0.4  $\mu$ m. a - Vivarous control; activity within bounds of physiological norm, mag. 33,000; b,c,d - Flight rats: b - in state of extreme excitation with blockade of synaptic transmission, mag. 42,000. c - state of excitation; mag., 33,000; d - in state of extreme excitation, mag., 25,000. S - synapse; S' - synapse in state of partial blockage of synaptic transmission; S'' - synapse in state of excitation; S''' - synapse with blockage of transmission; PS - post synaptic section of the dendrite of a granular cell; M - mitochondrion

P421(10/87)\* Anichin VF.

**[A study of] the receptor epithelium of the vestibular apparatus and the cochlea under exposure to acceleration and noise.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 48-53; 1986.

[14 references; 5 in English]

Neurophysiology, Vestibular Apparatus, Cochlea, Epithelium; Morphology and  
Cytology, Ultrastructure  
Rabbits, Guinea Pigs  
Acceleration, Noise

**Abstract:** Experiments were performed on rabbits and guinea pigs exposed for 5 minutes to acceleration of 10 g on a centrifuge. With respect to the utricular membrane, acceleration was either  $+G_x$  or  $-G_x$ . Noise exposure took place in a soundproofed room using high frequency noise with geometric mean of 2000 Hz and amplitude of 1000 dB. Animals were exposed to this noise either once or once a day for a week. After exposure the cochlea and vestibular sections of the labyrinth were isolated and processed using a specially developed method for obtaining and treating the entire membranous labyrinth very rapidly. Next, cross sectional specimens of the spiral canal were prepared for examination under an ordinary microscope. The vestibular portion of the membranous labyrinth was dipped in paraffin and sections prepared which contained all receptors at different levels. Fragments of the spiral canal were removed from the cochlea for examination by electron microscope. The vestibular section was separated into its components and 7 or 8 parts (utricle, saccule, ampoules of 3 semicircular canals, and 2-4 fragments of the spiral canal) were removed for study. Electron microscopy, histochemical, and karyometric methods were used.

Histological examination revealed that under exposure to  $+G_x$  acceleration, the otolith membrane was virtually flush with the apical surface of the utricular (re)ceptor, while there were always gaps between the membrane and the (re)ceptor under normal conditions. Under exposure to  $-G_x$  acceleration, these gaps were enlarged. Acceleration led to ultrastructural alterations in all the (re)ceptors of the inner ear, including the auricular ceptor. Most characteristic was the protrusion of a portion of the cytoplasm from the apical region of the support cells into the endolymph space. Submicroscopic changes were noted in all components of the sensory components. The cytoplasm of the hair cell showed lightening of the matrix, rounding and lightening of the mitochondrion or consolidation of the karyoplasm of the cell nucleus. The nerve endings were lightened, with enlarged mitochondria. Changes in the preganglionic myelinated nerve fibers of the vestibular and auricular ceptors varied in nature. The mitochondria as a rule were rounded and lightened. After exposure to noise, all ceptors of the inner ear underwent changes. Changes in the cochlea were identical to those described for acceleration. In the cytoplasm of the hair cells of the vestibular portion of the labyrinth many mitochondria were swollen and lightened, and the karyoplasm of many cell nuclei had thinned. In the majority of cases the nerve endings increased in size and contained lightened mitochondria. Calcification (not observed after acceleration) was noted in a number of hair and myelinated preganglionic cells in the basal region. Histochemical studies using nucleic acid revealed rhythmic pulsation of the nuclei of the vestibular and auricular ceptors after exposure to both noise and acceleration.

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Figure 1: Photograph demonstrating the methodology used

Figure 2: Histological sections of the utricle

Figure 3: Electron microphotography demonstrating ultrastructure shifts in vestibular ceptors on exposure to acceleration

Figure 4: Electron microphotography demonstrating ultrastructure shifts in vestibular ceptors on exposure to noise



P422(10/87)\* Yasnetsov VV, Pravdivtsev VA.

[On] the chemical sensitivity of neurons of the medial vestibular nucleus to enkephalin, acetylcholine, GABA and L-glutamate.

Kosmicheskaya Biologiya i Aviakosmicheskaya Biologiya.

20(5): 53-57; 1986.

[18 references; 10 in English]

Neurophysiology, Vestibular Nucleus, Chemical Sensitivity  
Cats

Physiologically Active Substances, Opioids, Opioid Antagonists, Neural  
Transmitters

**Abstract:** Experiments were performed on 9 curarized male cats under artificial respiration. While the animals were anesthetized access was gained to the rhomboid fossa and the cerebellum was aspirated. Microiontophoresis was used to deliver physiologically active substances to individual neurons of the medial vestibular nucleus. Reactions were recorded by microelectrodes to register extracellular electrical activity of individual nerve cells. The following freshly prepared solutions were used (0.03 M NaCl served as the solvent): met- and lev-enkephalin) - 0.02 M, morphine hydrochloride -- 0.05 M, naloxone hydrochloride - 0.01 M, ICI M 154,129 - 0.02 M. In addition water solutions of acetylcholine-chloride (0.5), GABA (0.5 M), and L-glutamate were used. All substances with the exception of L-glutamate were administered using a current with positive polarity; a negative current was used with the L-glutamate. Dose delivered to a cell varied. Evoked and spontaneous activity was recorded. The evoking stimulus involved tilting the subject laterally, to which all the neurons selected for analysis reacted.

Effects of the substances on spontaneous activity of neurons of the medial vestibular nucleus are presented in Table 1. Reactions of a given neuron to enkephalin and morphine were identical. Naloxone, a specific blocker of opiate receptors, arrested both inhibitory and excitatory effects of the enkephalins and morphine, suggesting that the effects of the opioids on the electrical activity of these neurons is based on interaction of these substances with the opiate receptors on the membranes of these cells. Since morphine is a selective agonist of mu-opiate receptors and lev-enkephalin of delta-opiate receptors and naloxone operates primarily on mu-opiates, these results suggest that the effects of the two substances are mediated by stimulation of opiate receptors of different types. To confirm this hypothesis, ICI M 154,129 a selective blocker of delta-opiate receptors was used. It was found that this substance completely prevented the effects of lev-enkephalin, but did not interfere with the effects of morphine. This is taken to demonstrate that there are mu- and delta-receptors on the membranes of neurons in the medial vestibular nucleus which control the excitation or inhibition of electrical activity of the cells. Results of this study indicated that effects of pentapeptides can be modified by neurotransmitter. In a typical case, the initial excitation of a neuron by enkephalin changed to inhibition when excitatory mediators, L-glutamate, and acetylcholine were added. This is interpreted to suggest that enkephalins may have a modulating effect on the cholinergic and glutaminergic synaptic transmission in the medial vestibular nucleus. Investigation of evoked activity showed that enkephalin and morphine had analogous effects on the reactions of nerve cells in this area. In general these substances enhanced the reactions of the neurons to the stimulation.

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In addition, it was found that , upon stimulation, lev enkephalin and acetylcholine could change an initial inhibitory reaction to an excitatory reaction. In the majority of cases, effects of the opioid peptides and morphine were decreased by administration of naloxone. However, in some cases, naloxone, which moderates the effects of opioids on the spontaneous activity of neurons, fails to block the effects of these substances on evoked responses. This is said to demonstrate the nonspecific nature of these effects. The specific antagonist of delta-opiate receptors, ICI M 154,129, blocked the effects of lev-enkephalin (delta-agonist) on evoked response, but not those of morphine (mu-agonist).

The authors draw the following conclusions: 1) neurons of the medial vestibular nucleus are highly sensitive to neurotransmitters (acetyl choline, GABA, L-glutamate) and the enkephalins, and approximately 80% of the nerve cells are inhibited or excited by microionophoretic administration of these endogenous and physiologically active substances. At the same time the activating and depressing effects of opioid peptides and morphine occur by stimulating of mu- and delta-opiate receptors, which are localized on the membranes of neurons of the medial vestibular nucleus; 2) enkephalins are modulators of cholinergic and glutaminergic synaptic transmission in the medial vestibular nucleus; 3) opiate receptors of various types (at the minimum mu- and delta-receptors), as well as their endogenous ligands the enkephalins, participate in perception and processing of vestibular information at the level of the medial vestibular nucleus.

Table: The effect of enkephalin, morphine, and neurotransmitters on the spontaneous activity of neurons in the medial vestibular nucleus

Substance	Total Neurons Tested	Excitatory Effect	Inhibitory Effect	No Reaction
Met-enkephalin	23	10	8	5
Lev-enkephalin	28	12	10	6
Morphine	20	8	8	4
Acetylcholine	12	8	2	2
L-glutamate	11	11	0	0
GABA	10	0	10	0

Figure 1: Effect of opioids, their antagonists and neural mediators on the spontaneous activity of neurons in the medial vestibular nucleus

Figure 2: Effect of opioids, their antagonists and neural mediators on the evoked activity (by lateral tilt) of neurons in the medial vestibular nucleus

P423(10/87)\* Karkishchenko NN, Dimitriadi NA, Molchanovskiy VV.  
**Pharmacological correction of the effects of Coriolis acceleration on the central nervous system.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina  
 20(5): 57-59; 1986.

[10 references; none in English]

Neurophysiology, Central Nervous System, Vestibular System; Human  
 Performance, Mental Work Capacity  
 Humans, Males  
 Acceleration, Coriolis, Countermeasures, Drugs, RNA

**Abstract:** The work described here investigated the effectiveness of drugs stimulating synthesis of ribonucleic acid (potassium orotate, pyracetame and riboxine) in preventing vestibular reactions and disturbance of the higher nervous system in response to Coriolis acceleration. Subjects were 131 healthy males, aged 19-26, with low vestibular tolerance. Motion sickness was induced by an unspecified procedure until the development of vestibular-autonomic reactions of degree II and III. Prophylactic effectiveness of the drugs was assessed on the basis of increase in duration of tolerance for a given acceleration. Electroencephalograms were recorded and short-term memory and mental work capacity were assessed. Potassium orotate was administered 3 times a day in a total daily dose of 40 mg/1 kg body weight for either 5-7 or 12-14 days [before acceleration]. Riboxine was administered on the same schedule in a dose of 22.5 mg/1 kg body weight. Pyracetame was administered once in a dose of 25 mg/1 kg body weight 2 hours before acceleration, and, in another condition, in a daily dose of 30 mg/1 kg body weight for 3, 7, or 14 days. Drugs were administered using a double blind procedure with placebos. EEG was recorded and cognitive tests administered before and directly following acceleration, with a follow-up after 14 days. The Wilcoxon statistic was used to test significance of differences.

With respect to EEGs, the most pronounced effect of Coriolis acceleration in the parietal-occipital leads was a decrease in the amplitude of spectral components in the range of 8-10 Hz. Acceleration led to a significant decrease in the number of words and numbers retained in short-term memory, and decreased speed and increased errors in a task involving searching for numbers in a table. When potassium orotate was taken for 12-14 days, pyracetame for 3 and 7 days, and riboxine for 12-14 days, there was a significant increase in statokinetic tolerance. Administration of these substances in other doses or schedules, and administration of placebos or scopolamine did not improve tolerance. [Editor's note: according to the table scopolamine had a significant effect in the comparison with pyracetame.] All the dosages noted as improving tolerance, as well as pyracetame administered for 14 days, normalized performance on the cognitive tests after acceleration. Previously described changes in EEG associated with acceleration were absent in subjects given potassium orotate for 12-14 days and pyracetame for 3 and 7. The authors interpret these results as demonstrating the effectiveness of the use of pyrimidine (potassium orotate) and pyrine (riboxine) predecessors of nucleic acid synthesis, as well as of a cyclic analog of gamma-aminobutyric acid and activator of RNA-polymerases (pyracetamine) in the prevention of motion sickness. The protective effect of potassium orotate and pyracetamine with regard to disruptions of higher nervous activity associated with motion

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sickness may be related to the nootropic effects of these substances. Changes in EEG spectral characteristics associated with motion sickness are not always normalized by drugs effective against motion sickness symptoms and cognitive disruption.

Table: Effects of medications on indices of statokinetic tolerance of subjects

Substance	Statokinetic Tolerance (in seconds)	
	before taking medication	after taking medication
Placebo	143.75	171.25
Scopolamine	135.56	149.44
Potassium orotate, 12-14 days	97.50	239.50**
Placebo	125.91	138.36
Scopolamine	128.50	161.80*
Pyracetame, 3 days	105.00	212.50**
Pyracetame, 7 days	127.92	280.83**
Placebo	114.00	106.88
Scopolamine	123.75	125.00
Riboxine, 12-14 days	112.50	228.00*

\*  $P < 0.05$ .

\*\*  $P < 0.01$ .

P424(10/87)\* Antipov VV, Drobyshev VI, Ushakov IB, Stepanova TP.  
**Responses to vibration of nerve cells in the kinesthetic sensor of rats.**  
 Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.  
 20(5): 60-64; 1986.  
 [17 references; 1 in English]

Neurophysiology, Nerve Cells, Kinesthetic Sensor, Morphology and Cytology  
 Rats, Males  
 Vibration, Noise

**Abstract:** This study used 76 male Wistar rats divided into 11 groups. Rats in group 1 were exposed once to whole body vertical vibration over a period of 1 hour; groups 2 - 5 were exposed to vibration once a day for 1 week, and 1, 2, and 3 months, respectively. Vibration frequency in all cases was 80 Hz, while acceleration was  $8 \text{ m/sec}^2$ . For each of the groups undergoing vibration, a control group was exposed on the same schedule to the noise of the vibration stand. Group 1 (and matching control) animals were sacrificed immediately after exposure, or 5 hours or 1 day afterwards. Animals in the repeated exposure groups were sacrificed on the day subsequent to the last exposure. Morphological analyses were made of the interorgan nervous systems of the shoulder and hip joints, peripheral nerves, spinal ganglia of the cervical and lumbar enlargements of the spinal cord, and portions of the sensorimotor region of the cerebral cortex. The nervous system of the joint capsule and the peripheral nerves were impregnated [substance(s) not specified]. The number of affected nerves in each specimen was counted. The neurocytes of the brain and spinal ganglia were stained [method not described] and the severity of damage to the central nervous system was assessed on the basis of number of neurocytes which were unchanged, slightly changed (reactive), and much changed (destructive). Neurocytes of the sensorimotor cerebral cortex were measured. Sections of the sensorimotor cortex were studied with an electron microscope.

Because no changes were found in response to vibration noise alone, the authors conclude that changes resulting from vibration and noise are mainly caused by vibration. With only a single exposure to vibration, reactions occurred in the neurocytes of the sensorimotor cortex. When exposure to vibration lasted for 1 week, reactive changes occurred in all the structures studied. After 1 month, these changes were more widespread and began to become destructive. After 2 months the rate of growth of the process slowed and after 3 months it remained at a constant level. In addition, 3 months of vibration led to the morphological equivalent of a compensatory-adaptive response.

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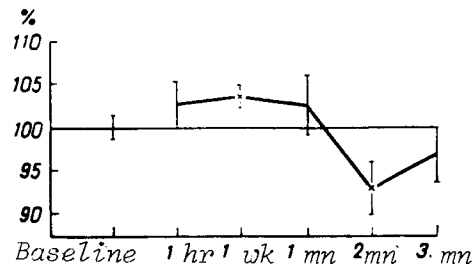


Figure 1. Changes over time in the size of the neurocyte nucleus in the sensorimotor cortex after exposure to vibration

Abscissa - period of exposure; Ordinate - size of the neurocyte nucleus (in % of control). \* - statistically significant difference. BK - biological control.

Figure 2. Changes over time in reactive and destructive changes in the nerves of the joints after exposure to vibration.

Abscissa - period of exposure; ordinate - number of changes in the nerves (in %); light bars - reactive changes; shaded bars - destructive changes.

Figure 3. Morphological changes in nerve elements in rats after exposure to vibration of varying duration

P435(10/87)• Shipov AA, Kondrachuk AV.

**The structure and function of the otoliths.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 11-19; 1986.

[35 references; 24 in English]

Neurophysiology, Otoliths

Review Article, Mammals

Mathematical Modeling

**Abstract:** This article reviews general knowledge about the structure and function of the otoliths. Mathematical models of various aspects of otolith response are discussed. Of these, only two are not available in English. The Bulgarians, Ivanova and Savova, hypothesizing that the submembrane space of a one-dimensional model of the otolith membrane contains a viscous fluid, described the hydrodynamics of fluid movement above and below the membrane. In this model, the macula of the otolith and the utricular membrane above the otolith were modeled as infinite planes. Because of the complexity of the resulting equations, the authors considered only uniformly accelerated motion. Gazenko and Chekhonadskiy modeled the otolith as a set of physical pendulums, represented as weights on a two-dimensional spring rigidly attached to the macula. When the macula bends with respect to the horizontal plane, or when inertia is operating, the weight shifts and the spring bends like the sensory hair of a receptor cell. These authors used a logarithmic transmission function to relate the magnitude of a stimulus and the frequency of pulsation. The authors criticize all the models described as having been based on a study (de Vries, 1950) performed with fish, whose otoliths are structured differently than those of mammals. In addition, these models, utilizing a one-dimensional representation of the otolith, are not sensitive enough to describe the dynamics of the otolith membrane which is a complex three-dimensional system with distributed parameters. Such systems have been studied widely in mechanics, but the mathematical models used in that field cannot presently be used to study the otolith because of insufficient knowledge of the otolith's structural properties and mechanical parameters. The authors strongly recommend experiments to refine understanding of the structure, physical characteristics, and mechanical parameters of the otolith membrane.

Figure 1: Structure of the otolith.

Figure 2: Characteristic curves of otolith receptor cells.

P444(10/86) Mel'nik CG, Shakula AV, Ivanov VV.

**The use of the electrotranquilization method for increasing vestibular tolerance in humans.**

Voyenno-meditsinskiy Zhurnal.

1986(8): 42-45.

[11 references; none in English]

Affiliation: USSR Medical Corps

Neurophysiology, Motion Sickness, Vestibular Tolerance

Humans, Males

Acceleration, Coriolis; Countermeasures, Electrotranquilization

**Abstract:** The "electrotranquilization" technique involves passing a weak current through the frontal lobes of the brain, supposedly producing a salutary effect on the limbic-hypothalamus-reticular system with respect to correcting autonomic disorders. In this study, effects of electrotranquilization on motion sickness symptoms were investigated in 15 healthy males. Electrotranquilization was achieved using a mass produced apparatus "Lenar" and electrodes applied to the forehead and mastoid process. Current was increased until the subject reported a sensation of warmth in the vicinity of the electrodes. The current level reached varied from 0.5 to 1 mA. Electrotranquilization sessions lasted 30 - 60 minutes, during which the subject could choose either to sit or lie down. Two types of trials were run. In the first series, a 30-minute electrotranquilization session was followed by exposure to angular and Coriolis acceleration (continuous cumulative Coriolis acceleration) to the point of pronounced nausea and urge to vomit. Dependent variables were tolerance time, rated symptoms of motion sickness, performance on a step test, pulse rate, breathing rate, and minute volume, blood pressure, and self rating of general state. In the second series of trials, subjects were exposed to increasing acceleration and tolerance time noted. Subjects then underwent a 60-minute electrotranquilization session and were reexposed to acceleration. Dependent variables were the same as in the first condition.

In the first condition, 4 subjects showed improved tolerance for acceleration (mean duration increase 220%) on both of two trials, 3 showed no improvement and an unspecified number improved on one trial and not on the other. In the second condition, electrotranquilization decreased the severity of rated motion sickness symptoms (from 7.8 to 4.5), and improved physiological parameters (see figures). In addition, electrotranquilization not only improved self-rated state when applied after onset of motion sickness, but improved tolerance for and recovery from subsequently induced motion sickness. In a control condition, tolerance time for a second acceleration session improved by only 19%; when electrotranquilization was applied between the two sessions, tolerance time increased by 76%. Similar effects occurred with rated symptoms, and self ratings. Electrotranquilization had no major effects on vestibular asymmetry (as manifested on the step test) after motion sickness induction. The authors recommend electrotranquilization, which they claim has no undesirable side effects for preventing motion sickness, as well as for accelerating recovery and diminishing its effects on work capacity.



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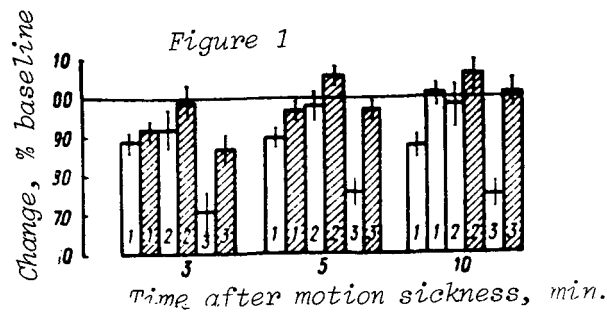


Figure 1. Effects of electrotranquilization on rate of recovery of cardiovascular and respiratory parameters after motion sickness (mean data obtained from 10 subjects over 20 trials)

1 - pulse rate; 2 - respiration rate; 3 - respiratory minute volume.  
White bars - control. Cross-hatched bars - electrotranquilization.

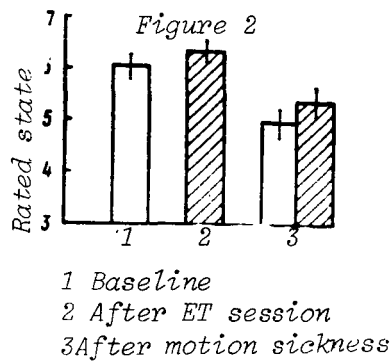


Figure 2: Changes in self-rated general state in subjects exposed to electrotranquilization between acceleration sessions (mean data obtained from 10 subjects in 20 sessions)

P445(10/86) Maksimuk VF, Skoromnyy NA.

**Changes in the functional activity of and blood supply to cortical structures of the brain in conscious rabbits experiencing motion sickness.**

See Digest Issue 8, page 73: P341.

Fiziologicheskii Zhurnal SSSR imeni I. M. Sechenova.

LXXII(7): 881-887; 1986.

[12 references; 2 in English]

Affiliation: I. M. Sechenov Institute of Evolution Physiology and Biochemistry (Comparative Circulatory Physiology Laboratory), USSR Academy of Sciences, Leningrad; School of Pediatrics (Department of Pharmacology), Crimean Medical Institute, Simferopl'

Neurophysiology, Brain Cortex; Cardiovascular and Respiratory Systems, Blood Supply; Biological Rhythms, Seasonal Variations; Adaptation Rabbits

Motion Sickness

**Abstract:** Experiments were performed on 18 rabbits of both sexes. Electrodes were implanted in the appropriate locations for the recording of local blood flow using the method of hydrogen clearance; ECoG (electrocorticogram) in the frontal, occipital, and temporal lobes of the cortex of the major hemispheres of the brain; total blood flow in the brain and area of confluence of the sinuses; EMG of the neck muscles and EKG. Blood pressure was measured by catheterization of the femoral artery. For experimental purposes, rabbits were held in specially designed cages which immobilized them in a relatively comfortable manner. Each rabbit underwent four series of trials. Condition 1 was a control condition during which baseline parameters were measured for a period of 2 hours; conditions 2, 3, and 4 involved first, second and third sessions during which the animals cages were swung at a radius of 1 m, amplitude of 90° and frequency of 30-35 swings per minute for 1 hour. [Note: tables and discussion imply that there were more than 3 sessions for each animal.] Interval between trials was 3 days. Swinging was interrupted periodically for 50-60 seconds to measure parameters, apparently in minutes 2, 5, 10, 20, 30, 40, 50 and 60 of the treatment. Parameters were recorded for an hour after the swing stopped. To investigate effects of seasonal changes, experiments were performed in both winter and in the summer.

The motion sickness inducing treatment led to stable changes in the values of all parameters measured, of which the most stable were changes in EEG frequency components. The experimental treatment increased local (in all areas) and total blood flow in the brain. These increases occurred first in the temporal (motor) region; this region also showed the greatest tendency for increased blood flow to diminish toward the end of the 60 minute session. [Not clearly reflected by data in table.] Blood pressure decreased during the experimental session, dropping to 80% baseline in the last 10 minutes. A nonsignificant decrease in heart rate was also observed during the session. Changes in EEG, heart rate, and tonus of skeletal muscles, in response to the treatment decreased from session to session, while blood flow in the brain increased somewhat. Changes in total bioelectric activity were more short-lived in the motor than in the visual and sensory areas of the brain. These changes became more pronounced during the second session, decreasing gradually in subsequent sessions. During the winter changes in electrophysiological parameters in response to the treatment were more pronounced and enduring than during the summer.

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session-to-session changes in blood flow were analogous in summer and winter, while session-to-session changes in ECoG returned to baseline values more rapidly in summer. The authors hypothesize that adaptative capability of the nervous system increases in summer, while need for increased blood supply during sickness-inducing procedures is analogous for both seasons.

Table 1: Changes in blood pressure, heart rate and blood flow in the brain in rabbits exposed to motion sickness inducing procedures (in % of baseline)

.uj 0		Experimental Treatment Duration, min.									Time Post-treatment, min.							
Base-	line	2	5	10	20	30	40	50	60	2	5	10	20	30	40	50	60	
(100%)																		
Blood Pressure																		
74		+1	+2	-4	-4	-7	-19	-20	-20	-16	-14	-12	-11	-11	-11	-7	-5	
mm Hg																		
Blood Flow in Temporal Region of the Brain																		
99		+18	+21	+25	+22	+35	+13	+14	+10	+28	+15	+15	-4	+4	+3	+6	+6	
ml/min/100 g																		
Blood Flow in Confluence of Sinuses																		
95		+17	+22	+35	+17	+19	+30	+26	+14	+20	+3	+19	+6	+11	+2	-2	+2	
ml/min/100g																		
Heart Rate																		
264		-3	-5	-8	-6	-7	-6	-5	-2	+2	+4	+4	+3	+3	+2	+2	0%	
per minute																		

Table 2. Changes in blood flow in the brain of conscious rabbits as a function of number of motion sickness inducing session (M)

Session Number	N	Base-line, ml/min/100 g	Changes in blood flow during treatment (min.; % baseline)								Post treatment blood flow (min.; % baseline)		
			1-2	5	10	20	30	40	50	60	2	10	20
Frontal lobe of the cerebral cortex													
1	11	99	+26	+12	-21	+11	+9	+13	-2	-14	-11	+5	+9
2	4	71	+1	+12	+23	+28	+28	+24	+22	0	+15	+14	+20
3+	12	80	+7	+18	+20	+24	+29	+26	+26	+11	+22	+20	+10
Temporal Lobe													
1	8	79	+9	+25	+27	+11	+20	+10	+8	+5	+17	+4	-7
2	3	123	+15	+25	+40	+11	+17	+5	+3	-16	-4	-6	-14
3+	5	120	+27	+20	+21	+30	+39	+27	+18	+29	+22	+40	+18
Occipital Lobe													
1	4	73	+21	+22	+26	+24	+30	+26	+27	+28	+17	+12	+41
3+	4	46	+2	+5	+43	+22	+16	+41	+41	+9	+12	+6	+10
Confluence of Sinuses													
1	6	91	+13	+9	+32	+8	+12	+22	+16	+29	-12	+31	+18
2	3	107	+15	+14	+26	+20	+8	+13	+18	0	-7	-6	-5
3+	6	94	+23	+37	+40	+27	+30	+50	+36	+15	+19	+23	+15

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Figure 1. Histogram of changes over time in frequency components of ECoG during and after motion sickness induction (rabbit # 2)

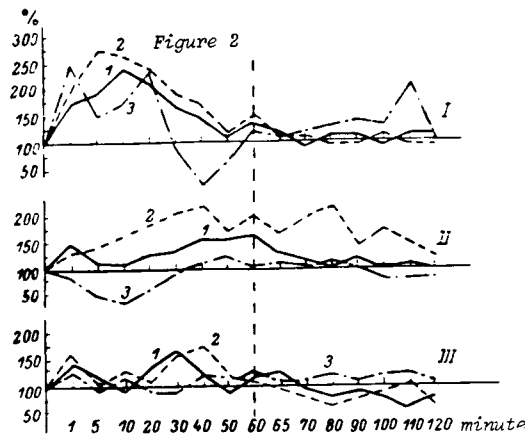


Figure 2. Changes over time in total bioelectric activity in frontal (unbroken line), temporal (dotted line), and occipital (dotted and dashed line) leads from the cerebral cortex of rabbits during and after induction of motion sickness, obtained in December

Abscissa - time, minutes; Ordinate changes in intensity of ECoG in % of baseline. I, II and III - first, second and third motion sickness induction.

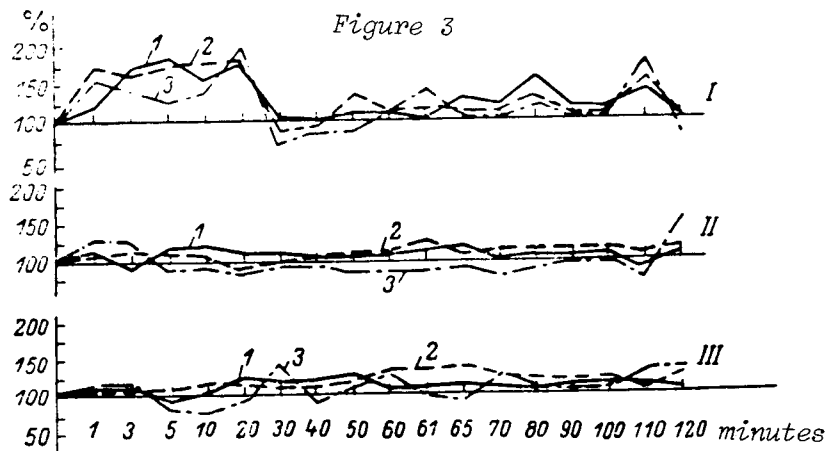


Figure 3. Changes over time in total bioelectric activity in frontal (unbroken line), temporal (dotted line), and occipital (dotted and dashed line) leads from the cerebral cortex of rabbits during and after induction of motion sickness, obtained in June-July. Legend as in Figure 2.

## NUTRITION

(See also: Metabolism: 413)

### PAPER:

P412(10/87)\* Kalandarov S, Bychkov VP, Frenkel' ID.

**Nutritional compensation for effects of hypokinesia and emotional stress on levels of histamine and serotonin.** [NB: although this is the title of the paper, nutritional compensation is only involved in the second experiment.] Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 31-34; 1986.

[14 references; 1 in English]

Neurophysiology, Histamine, Serotonin; Metabolism

Humans

Hypokinesia, Head-Down Tilt, Psychology, Stress; Nutrition, Vitamins, Mineral, Glucose, Phosphatides; Hypobaria

**Abstract:** Three experiments were performed with a total of 48 individuals aged 23-41. In the first, concentrations of histamine and serotonin were measured in the blood of 3 groups of 6 subjects who were subjected to bed rest, the first group with head elevated  $6^{\circ}$ , the second group with head-down tilt of  $-2^{\circ}$ , and the third with head-down tilt of  $-6^{\circ}$ . [Treatment duration not specified, but measurements were apparently made on days 2, 12, and 26 of treatment and at some point during readaptation.] In the second series of experiments, histamine and serotonin were measured in 10 individuals subjected to emotional stress induced by ascent to 8000 m as simulated in a barochamber, anticipation of linear acceleration on a centrifuge [apparently acceleration never actually occurred], and the requirement for performing a cognitive task under speed-accuracy instructions. All subjects were exposed to all 3 stressors [apparently, at intervals of a number of days], but half were given 3 nutritional supplements containing vitamins, minerals, glucose and phosphatide concentration. Components of this supplement were selected because of their value in metabolism and the increased need for them under conditions of physiological stress. The first supplement administered before "ascent" consisted of 1 multivitamin tablet, 180 mg ascorbic acid, 200 mg pangamic acid, 60 g glucose, 1.1 g potassium, 34 mg magnesium, 305 mg phosphorus, 1 g chlorine, and 300 mg calcium. Before anticipation of linear acceleration, subjects received the same supplement, with the exception of the multivitamin, and before the psychological test, subjects received the multivitamin, 180 mg ascorbic acid, 60 g glucose and 80 mg phosphorus. Subjects received these supplements for 5 days preceding exposure to the stressor and on the day of the exposure. Blood measurements were made in a baseline period, and at unspecified points before and after exposure to the stressor. In the third experiment, subjects were isolated in a hermetically sealed chamber with an atmosphere having increased concentration of ammonia of 2.1, 5.1 and 9.8 mg/m<sup>3</sup>. For half the subjects microclimate in the chamber was ideal, and for the other half it was poor. All subjects consumed a standard 3000 calorie/day diet containing all required nutrients. Blood concentrations of histamine and serotonin were measured fluorometrically.

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In experiment 1, subjects undergoing bed rest with the head elevated showed a statistically significant increase in histamine in the blood on day 12. Those exposed to head-down tilt showed a small decrease in histamine concentration on day 12 [contradicted by the table for group 3 ( $-6^{\circ}$ ). The concentration of serotonin in the blood was significantly decreased on day 12 for the group experiencing head-down tilt of  $-6^{\circ}$ . In the second experiment, for the group not receiving nutritional supplements, ascent in the barochamber was accompanied by an increase in histamine level, with an accompanying decrease in histaminopeptic acid activity in blood serum. When these subjects were anticipating linear acceleration and after the performance of a demanding mental task, histamine levels dropped, while activity of histaminopeptic acid remained close to the norm. When the nutritional supplements were used stressors induced no significant changes in histamine concentration in blood, nor in histaminopeptic acid activity. When no supplements were used, only anticipation of linear acceleration led to an increase of serotonin in the blood. With nutritional supplements, serotonin increased slightly on the day of exposure to the barochamber, with some decrease in serotonin associated with the other stressors. In the third experiment, with optimal microclimate, concentration of  $2.1 \text{ mg/m}^3$  ammonia had no effect on the blood parameters. When the concentration of ammonia was increased to  $5.1$  and  $9.8 \text{ mg/m}^3$ , histamine levels decreased. Under conditions of high heat and humidity in combination with ammonia in the atmosphere, histamine levels dropped. No effects on serotonin were noted in experiment 3. The authors conclude that simulation of space flight factors disrupt the equilibrium of metabolic processes, leading to long term changes in the relationship between histamine and serotonin, accompanied by decrease in histaminopeptic acid activity. Such changes could lead to allergization. Since results with nutritional supplements and psychological stress were positive, further research on their normalizing influence on reactions to simulated and actual space flight is recommended.

Table 1: Changes in the concentration of histamine (in nmole/liter) and serotonin (in umole/liter) in blood of subjects exposed to hypokinesia

Table 2: Changes in the concentration of histamine (in nmole/liter) and serotonin (in umole/liter) in blood of subjects exposed to psychological stress

Table 3: Changes in the concentration of histamine (in nmole/liter) and serotonin (in umole/liter) in blood of subjects isolated in a hermetically sealed chamber

**PERSONNEL SELECTION:** See Biological Rhythms: 408  
**PSYCHOLOGY:** See Cardiovascular and Respiratory Systems: P447; M101;  
Metabolism: P419; Nutrition: P412

#### **RADIOBIOLOGY**

(See also: Biospherics: M103)

#### **PAPER:**

P432(10/87)\* Sidiyakin VG, Temur'yantz NA, Yevstaf'yeva YeV,  
**Biochemical and morphological changes in the blood of rats exposed to a variable magnetic field in the infrared range.**

Kosmicheskaya Biologiya i Aviakosmicheskaya Meditsina.

20(5): 90-91; 1986.

[9 references; 1 in English]

Hematology, Biochemical and Morphological Parameters; Adaptation

Rats

Radiobiology, Magnetic Field, Variable, Infrared

**Abstract:** In this study, 200 outbred male white rats were exposed between 9:00 a.m. and 12:00 noon daily to a variable magnetic field with frequency of 8 Hz and inductance of 0.0005 mT. Vivarous and synchronous control groups were used. Blood was taken from the rats (10-20 in each group) after sacrifice on days 1, 2, 3, 6, 21, 28, 38, and 45 of exposure to the field. Concentrations of total lipids, total cholesterol, cholesterol in alpha lipoproteins, beta-lipoproteins, triglycerides, alanine- and aspartate amino transferase were measured. In addition, concentration of cholesterol in liver tissue and total number and morphological composition of blood leukocytes were determined. Multiple comparisons were tested using the t statistic. On days 9, 22, and 45 there was a decrease in total cholesterol in the blood in rats exposed to the magnetic field. Concentration of cholesterol in liver tissues decreased on days 6, 22 and 45. On days, 6, 22, and 45, the number of leukocytes increased substantially in experimental animals. The number of neutrophils was below control level throughout the period, while the number of eosinphils and the ratio of lymphocytes to neutrophils with segmented nuclei tended to increase. The authors describe these early changes as adaptive activation. On day 45 a conditioning response (not further specified) was noted.

P448(10/87) Vladimirov VG, Kamenko IP, Poddubskiy GA, Smirnova SM, Tarnopol'skaya LG.  
**Optimization of the composition of the radioprotective compound APAETP+ Mexamine and study of its action.**

Radiobiologiya.

XXVI(4):495-498; 1986.

[10 references; none in English]

Affiliation: S.M. Kirov Academy of Military Medicine, Leningrad

Radiobiology, Survival Rate

Mice, Male

Gamma Radiation; Radioprotection, Dose Optimization, APAETP, Mexamine; Mathematical Modeling

**Abstract:** The combined use of APAETP (S-(omega-aminopropyl)-beta-aminoethylthiolphosphate) and mexamine for radioprotection has been studied intensively. However, there is no published information about the possible interactions of these substances. Most experimenters have simply used the maximum tolerated dose of each, which may not be the optimal combination. This work investigates the radioprotective efficacy of various combinations of the two substances. Subjects were white male outbred mice [number not specified] weighing 18-20 g. The animals were irradiated with <sup>60</sup>Co gamma-quanta at a dose rate of 0.4 Gy/min. APAETP and mexamine were administered intraperitoneally 20 minutes before irradiation in doses varying from 0.3 to 1.0 LD<sub>50</sub>. The dependent variable was the survival of irradiated mice over a period of 30 days. Level of APAETP in tissues was determined on the basis of specific activity of tissue homogenates after introduction of <sup>35</sup>S-APAETP. A second order rotatable matrix was used to design the experiment. The data obtained were transformed into phi-values and used to construct a mathematical model. An equation was obtained relating survival (Y=response) to dosage of APAETP (A) and mexamine (M).

$$Y = 1.503 + 0.291A + 0.061M + 0.184A^2 + 0.321M^2 + 0.053AM.$$

A comparison of experimental and model values indicated that the model was adequate, allowing it to be used for the subsequent analysis. This analysis involved substituting a fixed dose of one of the components in the equation, varying the other dosage, and determining survival rate. Three fixed dosages of each component were considered. The phi-value was transformed into percent surviving using the formula  $p = \sin^2(\phi/2)$ . Analysis showed that for the three fixed doses of mexamine, increasing the dose of APAETP led to a uniform increase in survival rate. In combination with small and moderate doses of APAETP, either small (2.5 mg/kg) or large (11.5 mg/kg) doses of mexamine were more effective than moderate (7 mg/kg) doses. The most effective combinations were a high dose of APAETP and either a low (antagonistic interaction) or high (synergism) dose of mexamine. The seemingly paradoxical effect with moderate doses of mexamine is explained by the fact that low doses of mexamine do not interfere with the accumulation of APAETP in the tissues, allowing the full radioprotective effect of the latter to occur. Moderate and high doses of mexamine do interfere with this accumulation; however, in the latter case, the heightened radioprotective effect of mexamine compensates for diminished efficacy of APAETP.



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Table: Radioprotective effect of APAETP + mexamine

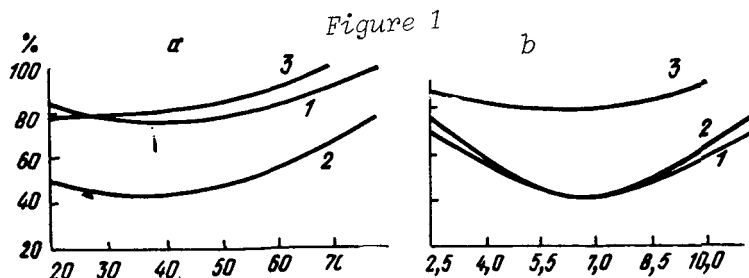


Figure 1. Survival of irradiated mice receiving APAETP + mexamine  
a - as a function of dose of APAETP with fixed levels of mexamine:  
1 - 2.5; 2 - 1.0; 3 - 11.0 mg/kg.  
b - as a function of dose of mexamine with fixed levels of APAETP:  
1 - 20; 2 - 50; 3 - 80 mg/kg.  
Abscissa: a - dose of APAETP; b - dose of mexamine; Ordinate - survival rate, %

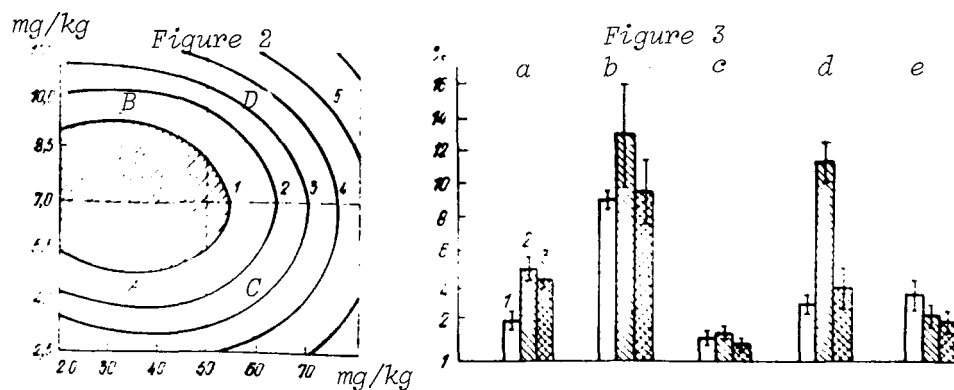


Figure 2: Changes in survival of mice 1 - 50%; 2 - 60%; 3 - 70%; 4 - 80%; 5 - 90% receiving various dosages of APAETP and mexamine in combination  
Abscissa - APAETP dose, mg/kg; Ordinate - mexamine dose, mg/kg

Figure 3 - Effect of mexamine on the accumulation of APAETP in the blood (a), spleen (b), kidney (c), and mucous of the small intestine (d).  
1 - control (no mexamine); 2 - 2.7 mg/kg mexamine; 3 - 11.0 mg/kg mexamine.  
Ordinate : concentration of APAETP, % of administered dose.

## MONOGRAPH:

M98(10/87) Frenkel' LA, Kalmykov LZ, Lan'ko AI, et al. (Shantyr' VI, editor).

Radiobiologiya kostnoy tkani

[Radiobiology of bone tissue].

Moscow: Energoatomizdat; 1986.

[136 pages; 34 tables; 38 figures; 85 references]

Affiliation: Radiation Biochemistry Laboratory, Khar'kov Scientific Research Institute for Medical Radiology, Ukrainian Ministry of Health

**KEY WORDS:** Radiobiology; Musculoskeletal System, Bone Tissue, Mineralization; Developmental Biology; Metabolism

**Annotation:** The authors cite the results of their many years of research on the submolecular, molecular, cellular, and organismic levels, as well as published data, as a basis for describing the dynamic, structural, and functional aspects of the integration of metabolism and processes responsible for mineralization and demineralization of bone tissue during development and natural aging of an organism. Postradiation modification of these processes leading to disruption of basic ion exchange and mechanical support functions of the skeletal system is also described. The authors present the principles underlying bone dosimetry and describe bone-equivalent dosimetry which is used to determine the absorbed dose of radiation on the basis of knowledge of the major components of bone tissue. This book is intended for radiobiologists, X-ray technologists, biochemists and biophysicists, as well as specialists in space biology and medicine.

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## SPECIAL FEATURE: THE "MIR" SPACE STATION

Translation of article by I. Pochkayev, A. Serebrov, Soviet cosmonaut, and V. Ul'yanov.

Aviatsiya i Kosmonavtika, 11/86, pp. 22-23.

The new Soviet space station "Mir" is the natural successor to the "Salyut" stations, and will be used in the solution of a broad range of problems related to the peaceful utilization of space. "Mir" will serve as the core module for the assembly of a multipurpose, continually operating complex with dedicated orbital modules for work on problems of scientific and economic significance.

The station will have six docking ports. Five of these are located in the transfer module (in the nose), and the sixth in the equipment module. The dedicated modules will first approach the front axial port and dock and then will be transferred by the manipulator to one of the lateral ports. The multipurpose orbital complex will also include the "Soyuz-T" and "Soyuz-TM" manned spacecraft and "Progress" series unmanned cargo ships.

In the future, dedicated orbital modules will be added to the complex, considerably expanding its scientific and technological capabilities. When this occurs, the station will serve as a central command post for controlling all systems of the complex.

The physical dimensions of the "Mir" station are, in many respects, similar to those of "Salyut": total length -- 14 m, maximum diameter -- 4 m, weight -- ca. 20 tons, open space in the modules -- 100 m<sup>3</sup>. The station was placed in orbit by the "Proton" space booster, after which the solar control batteries and antenna were activated by commands from Flight Control Center, and the station began to operate automatically and autonomously. With the arrival of the first crew, L. Kizim and V. Solov'yev, the complex began to function as a manned unit.

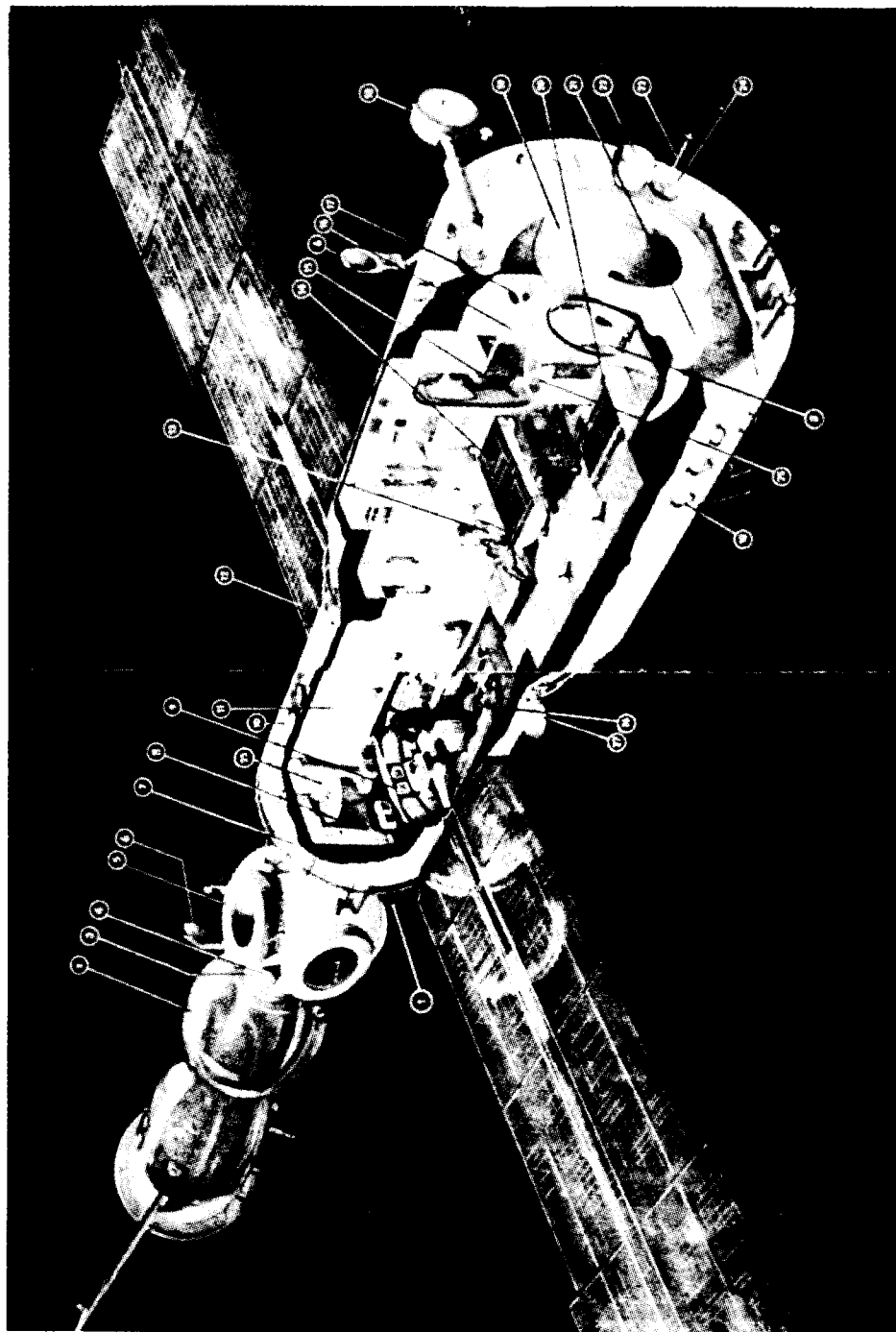
The station consists of the transfer, working and equipment modules, a connecting chamber, and two adjacent hermetically sealed airlocks. The transfer module, spherical in shape with a diameter of 2 m, has 5 passive docking ports. The central port is located on the longitudinal axis of the station, while the lateral ports are displaced from it by 90°. The shell of this closed, thermally insulated module contains the ports for the module docking system, the antennae for the approach radio apparatus, television cameras to monitor approach and docking, running lights, and devices for monitoring mutual orientation when the spacecraft is berthed manually.

The transfer module contains the thermal regulation and atmosphere maintenance units, and equipment for inflight measurements, radiocommunication, television, and lighting.

The working module consists of two cylinders differing in diameter and linked by a cone. To make it easier for the cosmonauts to orient themselves within this module, the floor, walls and ceiling are painted in different colors. The outer surface of the module contains solar batteries and sensors, radio communications system antennae, handholds for EVA, and windows. The smaller cylinder, called the work area, is the major place

# "MIR" SPACE STATION

ORIGINAL PAGE IS  
OF POOR QUALITY



## "MIR" SPACE STATION

- |                            |                                      |                       |
|----------------------------|--------------------------------------|-----------------------|
| 1. Core                    | 15. Private cabins                   | 22. Engine with cover |
| 2. "Soyuz-T" spacecraft    | 16. Toilet                           | 23. Docking target    |
| 3. Transfer module         | 17. Washroom                         | 24. Equipment module  |
| 4. Manipulator port        | 18. Satellite communications antenna | 25. Hatch cover       |
| 5. Lateral docking ports   | 19. Axial docking port               | 26. Window            |
| 6. Approach-system antenna | 20. "Treadmill" exerciser            | 27. Window screen     |
| 7. Working module          | 21. Connecting chamber               |                       |

## "MIR" SPACE STATION

where the crewmembers perform their assigned tasks. It is from here that the cosmonauts control the space complex and monitor the status of its systems. In the lower portion of the compartment are the instrument panel for controlling and monitoring the station's systems, optical sights for orientation, astroorientation and navigation instruments, and radio and television equipment.

The larger area, the living area, has been configured and equipped to create living conditions for the crew which are as comfortable as possible. There are two private cabins, one on the starboard, and one on the port side. These create relatively Earth-like conditions for sleep and leisure, and allow the cosmonauts to see through the windows. Seated on the fold-down chair, a cosmonaut can read or make notes. Sleeping bags are arranged vertically along the cabin's side wall, with a mirror on the wall opposite. The cabin contains equipment for lighting, ventilation, personal hygiene, and a set of toilet and other personal articles.

On the starboard side, is the dining area. The fold-down leaves of the table contain panels for securing the food in weightlessness; alongside are disposal bags for food wastes. Inside the table is an electric unit with controls for heating food. Opposite, on the port side, is the refrigerator. The dining area can accommodate 4 crewmembers at a time.

Next to the dining area is a multipurpose physical exercise machine. Behind a screen is the sanitation facility, the washroom, waste receptacles and containers, water tanks, fans, and a cabinet for toilet articles. Under the floor of the living area is an airlock for waste disposal.

The connecting chamber is at the rear of the core and contains a passive docking port. Cosmonauts pass through this area when they go from the spacecraft [Soyuz] to the core station [Mir]. The connecting chamber contains equipment for docking, water supply, radio communications, and other systems supporting station functions, and also personal hygiene equipment.

The equipment module is not distinguishable from the outside as a separate module. It is contained in the same outer shell as the working module, 4 m in diameter. It can be identified by the words "Mir" and "SSSR" clearly marked on its outer surface.

The equipment module contains propellant tanks filled with fuel and oxidants, the vernier engines, and low thrust engines for controlling the course, bank and pitch of the core, and equipment for the heating and docking systems. Outside are beam antennae oriented to the communication satellite retransmitter, which allows communications between the crew and Earth to occur when Mir is outside the radio visibility zone and beyond the range of ground-based tracking stations. On the outer rim of the equipment module are navigation running lights and solar sensors.

The complex has been equipped with computers which provide a powerful information processing system, permitting maximal automation of flight control and flight program performance. A display and keyboard provide monitoring and analysis of the status of the onboard digital computer, display of instructions and reference information, and interactive dialogue. The computer station displays commands and emergency warning

## "MIR" SPACE STATION

messages, and allows the cosmonauts to monitor and control the propulsion, power supply, lighting, waste disposal, and water reclamation systems, and provides support for EVA and other functions.

The movement control system, consisting of optical sensors, visual orientation instruments, control consoles and levers, gyroscopic instruments, and a set of multiplexing-logical and data conversion units, is used to maintain orientation when the station is on automatic pilot, as well as for manual orientation and stabilization. In manual orientation mode, the crew achieves high accuracy by using the optical sights and sextants to orient the station's axes with regard to local vertical, the Earth's horizon, i.e., the motion of the underlying surface, or the stars. The crew uses the command console and control lever to generate and transmit appropriate commands to the station's propulsion system.

The integrated propulsion system includes the low thrust jet system and two high thrust engines. The former generates momentum for controlling the motion of the station relative to its center of inertia, creating small changes in motion parameters. The low thrust engines are located on the core's outer hull. The high thrust engines are located in the forward end of the equipment module and are used to make large changes in the orbital parameters of the station. These engines are fuelled with compressed gas, stored in tanks. Refuelling from the cargo ship takes place through special hydraulic joints in the docking ports. Cosmonauts control and monitor the operation of the propulsion system from consoles located in the living area of the working module.

The power supply system provides electricity for the instruments and systems of the core, docked cargo spacecraft, and dedicated modules, and charges their storage batteries. This system consists of the solar and storage batteries, and automated devices for control and telemetric monitoring. The size of the solar battery panels has been expanded from what it was in "Salyut-7," from 51 to 76 m<sup>2</sup>. Efficiency has also increased through use of components made of gallic arsenidine. The panels are positioned perpendicular to the sun's rays, by means of special drives controlled by signals from solar position sensors. The station contains several storage batteries connected in parallel to the primary source of electricity -- the solar batteries.

In each orbit, the station spends 40% of the time in the Earth's shadow. At the same time, consumption of electricity alternates between low demands during crew rest periods and relatively high demands when the control, television, scientific research, and communications systems are activated. A buffer storage battery serves as a highly versatile power source during peak demand and creates the stable conditions desirable for equipment operation. If necessary, the power of the electrical network can be increased by utilizing the reserve storage batteries.

The automated electricity control devices protect the storage batteries from long periods of discharge or overcharge, monitor power system parameters, and implement control from Earth or the core station.

## "MIR" SPACE STATION

After the cargo ship docks with the "Mir" station, the two electrical power systems are merged. The buffer storage battery of the spacecraft is stored in a charged state, and the solar battery is hooked up in parallel with the solar battery of the core to form a single electrical supply system.

There are 4 main types of light on the station: general, working area, local illumination and brightness regulation. They can be turned on from central and local illumination control panels located in the various modules. All the modules have sockets for providing electricity for portable apparatus.

The thermal regulation system is a set of devices which maintains the temperature and humidity of the onboard equipment and apparatus the station within specified limits, and does the same for air temperature and humidity within the station. This system provides ventilation within the core station, cargo ship, and dedicated modules. The system is comprised of sensitive elements, sensors for monitoring the temperature of the equipment and air, units for automated and manual regulation systems, servo elements, and heat exchange units, which allow excess heat to be dissipated in space.

The majority of the hydraulic components of the system are located on panels outside the station. Heat and moisture exchange among the core, the cargo ship and the dedicated modules is provided through use of detachable air ducts.

The thermal regulation system consists of external and internal heating and cooling loops and a linking system. This system maintains a temperature range of 18°-28°C. A preset temperature regimen is maintained on the station automatically, but the crew can also adjust heaters, air conditioners and fans manually. Every day the crew checks air temperature and humidity in all modules and cabins. Air composition in the core is monitored by gas analyzers.

The cosmonauts drink treated water delivered by the "Progress" cargo ships. The water is processed on Earth with silver ions and stored in 10-liter tanks. In this state it will remain potable for up to a year. The core also contains a system for reclaiming water from the atmosphere, similar to the one on "Salyut-7." The daily ration of water allotted to each cosmonaut is virtually the same as that on Earth -- about two liters.

Cosmonauts consume 4 meals per day. Daily rations consist of a variety of different types of food products. A day's ration would usually include tubes, canned foods, freeze-dried foods, bread, fruit, vegetables, tea and coffee. Dried food is mixed with cold or hot water from the water reclamation system before it is eaten and the freeze dried products may be restored.

The station has a refrigerator for food storage. Its temperature ranges from -3° to -10°, and it holds up to 40 kg. Like a terrestrial refrigerator, it must be defrosted. It is designed for easy repair and the major components are replaceable.

## "MIR" SPACE STATION

The washing facility can be used in space under conditions close to those on Earth. It consists of a spherical shell with slots on the side for the hands and in the upper portion for the face. However, the amount of water, allowed for washing, 0.3 liters per person, is far from what it is on Earth. Small sponge-like packets are used to supply the cleansing agent. After water has been used, the cabin is cleaned with special wipes.

The toilet, housed in a separate compartment, is equipped in almost the same way as on Earth. The only difference is a special flushing and ventilation system. Sanitary and hygienic articles include underwear and exercise clothes, sleeping bags, and personal toilet articles. The station is cleaned periodically with a vacuum cleaner and damp cloths.

For exercise the station is equipped with a bicycle trainer and a running track. In addition, there is a set of expanders, a "Penguin" suit, and a "Chibis" vacuum (LBNP) suit.

During one of the communication sessions, L. Kizim reported, "the station is pleasant, bright, spacious, and clean." The opinion of this cosmonaut, a veteran of three space stations, implies that the Mir is truly outstanding.

The period during which the crew concentrated on getting acclimatized to the monotonous rhythm of life on the station did not last long. On March, 19 the unmanned cargo ship arrived at the station and the "Mir"- "Soyuz-T-15" - "Progress-25" complex was assembled. The cargo ship brought apparatus to further equip the core, fuel, [scientific] instruments, food, and of course, the long-awaited mail.

It should be noted that unloading in space is no easy matter. The cosmonauts had to remove the equipment and apparatus, which had been bolted in place, in a strict order, the reverse of the order in which it had been loaded on Earth. But on Earth it had been packed by brawny fellows who had tightened the screws and bolts for all they were worth. This was the reason L. Kizim and V. Solov'yev kept asking during the communications sessions, "By the way, what instruments are you planning to send out next time? We're going to need some more wrenches."

After the "Progress-25" was unloaded and the station was refuelled, the crew tested individual onboard systems. Their reports, combined with telemetric data, indicated that the manned complex was functioning normally.

In accordance with the flight program, the crew tested the radio system which provides communication with Flight Control through the satellite retransmitter when the manned complex is outside the radiovisibility zone for contact with the USSR. The "Luch" ("Kosmos-1700") satellite served as the retransmitter. During the test, aside from the radio conversation, there was also a television broadcast. The radio and television signals traversed tens of thousands of kilometers to bring the cosmonauts' images and voices to Ground Control.

On 16 July at 16:36 Moscow time, the "Mayaki" crew returned to Earth, having completed the first stage of research and testing of the "Mir" scientific space station.



**SPECIAL FEATURE: GROUP DYNAMICS/PSYCHOLOGY**  
**DIARY OF PARTICIPANT IN SOVIET ISOLATION EXPERIMENT**

Translated from journal Sovetskaya Rossiya 8 August 1986,  
**A year's expedition: From the diary of Andrey Bozhko, subject in an experiment to test space technology.**

**5 November (17:15).** We enter the chamber, German Manovtsev, Boris Ulyshev, and myself. There are a great many people applauding in the balcony of the huge hall where our "space ship" has been erected. The spacecraft door closes behind us and the first few minutes of our voyage pass. They have divided the duties up among us. German, the captain and a physician, is responsible for performing inflight medical tests and monitoring the day-to-day health of the crew. Boris is responsible for monitoring and maintaining the life support system hardware, and I will work in the greenhouse on biological experiments.

Let's see, what do I know about these fellows? German graduated from the First Moscow Medical Institute and is now a scientific associate of the Scientific Research Institute. He has already participated in isolation chamber experiments, that is, he has lived for long periods in hermetically sealed rooms with simulated space flight factors. He was "roasted," as he puts it, experienced oxygen starvation and served as a guinea pig with respect to noise and vibration. He is an experienced subject and the oldest of the three of us.

Boris is the youngest and a decent engineer. He tells us that the most memorable event of life was his service in the army.

After supper we drew lots for the bunks we would sleep on. I am to sleep on the lowest bunk for the next 10 days. German will sleep on the middle one, with Ulyshev on the top. Then we will switch. There's is a real reason for this -- the concentration of oxygen is different at different heights in the room.

**6 November.** Watch officer: Manovtsev. Duties: food preparation, dish washing, sweeping, recharging the regenerative substances. Today we had a special lunch in honor of Boris' birthday. We kneaded dough and baked bread. We couldn't find any coffee and opened a tin of cocoa instead.

In the evening, German stuck his pipe in his teeth and sucked on it -- trying to pacify his urge to smoke. Boris looked at him with such longing that German suggested he do the same. Boris gladly agreed.

**12 November.** Today we have been in our hermetic quarters for a week. As before, I sleep on the floor. The individual monitoring belt which we wear at night causes some discomfort. These belts allow the medical people to use our respiration and pulse rates to monitor our condition as we sleep. Oh well, I guess I'll get used to sleeping "in harness."

We take the watch in turn. We are growing used to our freeze-dried food. We have had to overcome a number of psychological barriers, including prejudice against the drinking water used to prepare our food. After all, it has been made from the waster products of three men inside a "starship."

Each crewmember is allowed a total of 10 liters of washing water for a shower -- you just can't get yourself completely washed before it runs out. After 10 days, this same water, cleaned of impurities, will be used by another crewmember to wash with... We are trying to keep ourselves in shape -- every day, aside from the morning exercises, we also work out.

**17 November.** It is winter outside, but our climate here is always the same. One bad thing -- the humidity is high.

For the moment, time is still passing fast, especially when we sleep during the day. In the evenings we read, make notes in our journals, and occasionally watch television programs.

The air in our compartment is being studied not only by medical people and chemists, but also by biologists, who are testing for microbes. As for my own scientific research, evidently it is to begin after the greenhouse has "docked."

**5 December.** It has been exactly one month that the three of us have been in isolation. Probably, this will prove to have been the most difficult period -- it has been a month of getting accustomed to our environment, a test of all our characters. But the results have been rather encouraging. I hope that everything will go well in the future. German has changed. He has become quieter, more tactful and sensitive. Boris, who is not a bad comrade at all, is friendlier to me than to German. I hope that from now on our life will be simpler; after all, we have already gained a fair amount of experience.

**15 December.** Experience has shown that it is easier for two to live together than three -- it is simpler to develop relationships. In a triad, a third person can play on the conflicts between the other two. Something similar happens every day with us.

We are all still healthy. But we sleep poorly. Why? Evidently, memories and analyses of day-to-day events rob us of normal sleep.

The problem of the relations among the three of us has begun to concern me more and more because of my frequent quarrels with German. We are very different people in many ways, with different interests and educations. I am disturbed by the growing conflicts. They must stop .... We must act like rational human beings.

**23 December.** Today is Saturday. We sit and wait for dinner. Boris the day's watch officer, is fussing with the stove and has already achieved some results -- a smell of burning.

I no longer play chess with Boris. We have yielded too many moves to each other, it was leading to hostility. After a frank talk with German, the relationship between us has begun to improve.

**29 December.** The New Year is approaching. We are hardly aware of it. Today they told us that we were to have a tree and that a camera man had been to Boris's and my homes (German didn't want to participate) and we'd be shown the films on the 31st. Very pleasant news... Why did German deny himself this pleasure?

Tomorrow we will get our hair cut and put on holiday clothes, and the day after that we will have a festive meal. It's hard to believe that we will have a tree. A small living tree...

I went over in my mind the major events of the past year: I joined the party, obtained three author's certificates [Soviet equivalent of patents], and my laboratory work went well. I did a lot of work to prepare for this experiment. I can say without exaggeration that transferred to the Institute of Biomedical Problems of the USSR Ministry of Health solely in order to participate in this experiment. And yet now I have these stupid doubts: What am I doing here? Why can't I work under normal conditions like everyone else? It feels as if the experiment will never end. I wish time would pass faster. An endless number of times I have mentally urged this year, a year completely devoted to science to move faster. Joys are few. And yet science is the dream of many. And in our "spaceship" we give all our time to this dream. How could this be bad?

Relaxation here is something different than it is in ordinary life -- involving switching from one task to another. And it is best not to think about what is happening outside these walls....

#### DOCKING

**4 January.** We are getting ready for supper. Boris is on duty. We have just finished a strenuous work out, after which we sponged ourselves off with a damp towel. There wasn't any water for showers today.

Only here, in our particular circumstances, have I come to appreciate the true meaning of physical exertion. You continually have to overcome the reluctance of your body. This trains the will. "After all, a person who can conquer himself is stronger than one who has merely conquered a city," as I believe one of Ernest Hemingway's heroes said.

**5 January.** We are living with pleasant memories associated with the films of our families. This was the best possible holiday gift we could have received. Boris and I asked them to run the film twice and would have liked to have seen it again and again. After seeing it we wished everyone at the command point Happy New Year and began to prepare dinner. I was on duty and ruined the cabbage. I should simply have defrosted it, but instead I boiled it.

German is often gloomy -- could he be sick, not feeling well? I feel sorry for him.

Our dreams have become an additional source of new information and are no more difficult to interpret than the rare television programs we get to see, which greatly help us cope with our isolation, and overcome our unique form of "information deficit."

The experiment, of course, benefits us as well -- particularly when it comes to developing a sense of self-criticism. Under living conditions like these, you can't limit yourself to noticing other people's mistakes, when it's clear you make your share yourself. Recently, Boris said that our life will help him to improve his relationship with his wife. But there is no intimacy. Right now, it seems to me that neither Boris or

German could ever become a real friend. The only thing that really unites us is the desire to bring this experiment to its conclusion.

**27 January.** Today is a special day for us -- the living compartment has docked with the greenhouse. We have long awaited this event. For me, the greenhouse is a laboratory, the beginning of my scientific work. And to all of us, it signifies an extension of our living space, the availability of a sports "field," and finally, it is a "garden," giving rise to strong positive emotions, as well as fresh greens for our table.

The command post gave me the assignment of opening the door to the greenhouse module. With great emotion, I turned the handle, opened the heavy, hermetically sealed door and entered the greenhouse.

My impressions were unforgettable: blinding lamps simulating sunlight, new smells, little surprises, gifts from our friends, a teddy bear, three toy cosmonauts made of wood, and a metal nightingale that sings when you wind it up and, most important -- fresh, juicy greens, which we had not seen for several months. At our request, a horizontal bar has been installed in the greenhouse and a small passage has been left between the potted plants, giving us a chance to do more than run in place. It would be hard to describe our joy at seeing the plants.

**29 January.** I go out into the greenhouse module. The lamps shine overhead -- our artificial sun. Here it is "day" for 14 days, and "night" for 14 days. The alternation of day and night follows the lunar cycle. This schedule has determined which plants were selected for cultures: in our greenhouse we raise quick-growing, leafy plants, which increase their biomass rapidly: bok choy, garden cress, borage, dill. The growth area is 7.5 square meters. Because of the greenhouse we will have a daily average of up to 200 grams of fresh greens for the three of us.

**7 February.** We have had several harvests. Our work immediately increased: you have to be on watch and at the same time tend the plants. I feel pretty good, much better than before. February 15 is German's birthday. I must try to treat him with more consideration. He has managed to catch a cold and get sick, and Boris too is beginning to get a sore throat and is gargling with a decoction of eucalyptus leaves. I notice that my companions are often sad. It is easier for me -- I am not married and have no one to yearn for. German often longs for his home and family. Boris misses his wife and little daughter, Svetlanka. He often gazes at their photographs and leafs through old letters.

Without saying anything, Boris showed me some blood on the edge of a cup. German, embarrassed, confessed that his gums were bleeding heavily. He said that Boris and I would soon experience the same thing: our food is too soft, and our teeth are not getting the proper exercise. Now German is asking a medical specialist to have them make and give us special chewing gum to strengthen our teeth.

**14 March.** I have just taken a shower -- there wasn't enough water. I have already gotten over my fastidiousness and am no longer bothered at the thought that someone else has already washed with this water. I am ready to say it again and again: the worst thing about this experiment is having to live together. One feels it would be easier to be totally alone.

In isolation, there is much to remember, much to reevaluate and, in general --- if you don't count the effect on my overall state of health -- the experiment has been of personal benefit to me: I spend more time "sifting" through my thoughts and this is not a bad thing.

**23 March.** German, as usual, got up first to read parameter values into his tape recorder. Our scientific director called and told us that they have decided to create a so-called "emergency situation" for 10 days. Thus, soon we can expect changes for the worse in our living conditions. Probably, this will be a good thing. I, of course, understand that the circumstances of our lives will become even more difficult, but we have come to the point where we are dying for any changes at all in our daily routine.

**5 April.** A Spring day. For several days now I haven't touched my journal. And it all began on that day when a new female voice was heard among our support group. During my duty watch, I spoke to the girl for the first time and grew sad: "Could it be that this will go on all through the spring?" I saw a crack in the blinds. At that moment, a girl came up and closed them. Could it be her? Almost exactly as I had imagined her: young and beautiful. From that day on, I had no peace, I completely lost my previous spiritual equilibrium. The thought came into my head: what if I were to write her a note? My journal, my true and silent friend, was neglected during those days. I wrote a letter to Violet. I wrote it and tore up what I had written, wrote another one, and tore that one up too...

#### RETURN

**12 April.** I woke suddenly during the night out of a very simple dream of flying. Then I remembered: today is 12 April -- Cosmonautics Day. I forced myself to think about pleasant things, the coming holiday dinner, and the fact that 6 out of the 12 months of our "space" voyage have already passed. They are using us to test new technology for life support systems. Using nothing more than our native physical and psychological capacities, we can do a great deal to help those who at some future time will orbit the Earth in space stations on long-term space flights. This thought warms the soul. But my mind keeps returning stubbornly to the present. I picture the remaining six months of our trip in gloomy colors: the dull daily routine, the numerous medical tests, biological and psychological experiments, and the strained relationships between three people isolated from the rest of the world behind steel walls.

I remember at the clinic, before they picked the crew, the doctors in charge asked me who I would choose as traveling companions. I named neither German nor Boris, but two other fellows, people I really liked and would have loved to have as partners.

How irritating unnecessary words are, and how old-hat everything seems: after all this time the language of facial expression and gestures has become only too clear to us. Everything is familiar to the point of surfeit. We all know exactly what we have to do for the research program, so that talking about it is not only superfluous, but annoying. Now I understand why, a few days ago, Boris, said nothing when German dropped the meat on the floor while preparing lunch, but only looked

meaningfully at the meat where it lay, then at me, and then stormed out into the greenhouse module. I turned my back and said nothing to German either. More or less the identical thing happened when German accidentally dropped the dish towel on the floor and stood on one corner while he continued to wipe the dishes with the other end. A triangle can get very complex: each of us has at some time been completely out off by the other two. This is very painful, even if you don't count the fact that you need someone to cut your hair, or scrub your back when it finally is your turn for a bath. It's a good thing that we now have some place to escape to -- our first 4 months here there was nowhere: all we had was the 6 square meters of our living quarters.

Each of us has a choice: either let whatever has offended you pass, refraining from noticing or hearing it, or react and immediately provoke a counterattack, further complicating your relationship. For a long while, I have been trying to follow the first principle.

My journal, which I write in daily, has saved me. It acts as my "lightning rod," I can pour out my feelings and the writing helps me focus on and analyze the events and details of our daily life, which otherwise would be forgotten. This was my original plan, and I am pleased that I have found the time to write every day, no matter how busy I am.

**16 April.** I have made one more small discovery: if a person is criticized, berated, or insulted, his normal reaction is to respond in kind. But if he is praised undeservedly, he begins to berate himself -- following a kind of homeostatic principle. Now I sit in the greenhouse and write. German is helping Boris get "dressed" for the night. He will sleep without his belt, but wrapped from head to foot in electrodes so they can study his night's sleep or, more likely, insomnia.

**6 June.** We have had a stress test on the ergometer. German, as usual, attached electrodes to my chest and put a pulse transmitter around my neck. He put on a blood pressure cuff and ordered: "Loading of 600 kilogram meters" ... I could scarcely get my breath, my head was pounding, I was covered with sweat.. All because of the temperature.

**12 June.** Finally, the "emergency situation" is over. This simulation of technical problems included changes in the microclimate -- not for the better. We endured sharp increases in humidity and temperature, periodic increases in the concentration of carbon dioxide with decreases in oxygen level, as well as a decrease in drinking water rations to 1.2 liters per person per day, no hot food, and a decrease in the day's ration by 500 calories per day. Yes, these 10 days have left an indelible impression. Listlessness, heaviness in the head, night watch duty, constant sleepiness, increased body temperature caused by overheating -- all this is behind us, and it seems as our surroundings have changed completely, even though this "10-day nightmare" took place right here. My birthday fell during the "emergency," so we postponed our celebration dinner by two days.

Our stomachs had shrunk during this period, so that we couldn't eat as much as usual and, involuntarily, were compelled to spread out our treat. I was given the usual -- flowers, daisies, complete with roots, -- and I carefully planted them in a dish with substrate soil-substitute and placed them in the greenhouse module. Whenever there are flowers, one or

another of us is always going out to admire them. I remember that during the first days of our isolation, even the two flies which, by some miracle, had been allowed to remain in our living quarters were a source of pleasure and no one tried to swat them.

**21 June.** German has confessed that he has been feeling ill for several days, because of a swelling behind his ear, which he had concealed this from us.

During our communications session, the surgeon recommended that German lance the boil. German performed the operation with our help: I froze the area which would be cut, and Boris bandaged his head after the operation. Now German has cheered up, although his head is still bandaged. The bandages do not prevent him from sticking his pipe in his mouth, pretending he is smoking.

**11 July.** Boris picks up his guitar and goes into the greenhouse where he strums it mournfully. He had promised he would teach me to play. Unfortunately, this turned out to be impossible. We could not cope with our emotions. Given the problems in our relationship, the assumption of the roles of teacher and student, even temporarily, turned out to be untenable.

Every once in a while we cut each other's hair, or to be precise, Boris gives German and me a haircut, while I give Boris one. Boris does a better job than I, while German refuses to even try. Evidently, this is one more thing which requires a good relationship. This evening Boris gave German a crew-cut. Given the conditions under which we live, such a haircut is the most sensible, since long hair takes more water to wash. This is why German shaved off his beard, which used to be his pride and joy.

Why is it that, in spite of everything, the relationship between us grows more complicated every day? I keep being reminded of depressing examples of alienation between people who find themselves living together under difficult circumstance, for example, an episode from the life of the famous Arctic explorer Fritof Nansen and his friend and assistant Johannsen. It took these highly self-disciplined and brave men nearly a year and a half to reach the North Pole from Franz Josef Land. They trudged across the ice in frozen clothing, which there was no way to dry, with raw, frozen meat their only food. For drinking water, they warmed bottles of snow against their bodies. But the hardest thing for them to bear was each other's company. Initially, close friends, they began to irritate each other so much that they virtually stopped speaking. The reason for their problems during their isolation has never been explained. Perhaps such "incompatibility" under conditions of isolation is the rule, not the exception.

We are not inherently hostile to each other, but how difficult it is sometimes to overcome extreme self-centeredness. We just have to learn to live with the fact that our relationship has become unbearable to all three of us.

**27 October.** The monotony of life has led to a sort of deadening of the memory and emotions -- right now I can't remember what we did yesterday.

5 November. Only 2 hours to before the end, "landing," the beginning of a new life. It's hard to believe. I don't believe that all this is real. We fold up our sleeping bags! Could this be the real thing and not a dream?

A. Bozhko, candidate in biological sciences, speaks:

"Eighteen years have passed since those glorious and difficult days. What has happened during these years? New, interesting work in the service of a noble dream -- the conquest of space. It's a shame, of course, that the new responsibilities of our jobs have separated our crew. But that year's experience has linked us inseparably, for a lifetime. Even right after the end of the experiment, when a reporter asked if we would prefer each other's company in another such experiment or long-term flight, we unanimously answered in the affirmative, since we knew each other significantly better than anyone else, and had passed the test of living together under extreme conditions.

A year of strenuous work did not pass in vain. German and I soon defended our candidate's dissertations, Boris became a leading specialist in control devices. The experiment also influenced my personal life. The pretty girl from the support group, with whom I tried to correspond, became my wife. German and Boris were at the wedding.





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